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AIR FORCE HUMAN RESOURCES LABORATORY

LIFE CYCLE COST OF C-130E WEAPON SYSTEM

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Human and material resource data accumulated from all available Air Force sources is used to calculate the approximate life cycle cost (LCC) of the C-130E Hercules aircraft. The data was located, collected and reduced to computer files under another phase of the study. The Air Force Cost Analysis and Cost Estimating (CACE) model was modified and used to calculate the C-130E LCC. Based on fifteen years of Air Force data (1962–1976) a LCC estimate was calculated.

The methodology for determining the historical LCC may be applied to other systems. The primary difficulty in computing historical LCC estimates is the lack of required data files and the low quality control on many data

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variables. This research provides a methodology and a guide for accomplishing historical LCC on other weapon systems. The reason for determining historical LCC is to establish a baseline that can be applied to new weapon system development programs to identify possible areas for redesign to reduce future weapon system LCC.

This document is the third of a series of five Technical Reports emanating from this Project 1959 Phase I study, namely:

AFHRL-TR-77-40	C-130E Hercules Aircraft: Review of Published Literature and Structured Interviews (Available to U.S. Government Agencies Only);
AFHRL-TR-77-48	Historical Analysis of C-130E Resources;
AFHRL-TR-77-46	Life Cycle Cost of C-130E Weapon System;
AFHRL-TR-77-64(I)	Historical Resource Utilization Methodology; and
AFHRL-TR-77-64(II)	Historical Task Analysis of C-130E Personnel.

SUMMARY

This report describes the results of a historical life cycle cost analysis of an existing Air Force in-service aircraft, specifically the C-130E Hercules. In compiling the Life Cycle Cost estimate, existing data sources were utilized with a current Air Force cost estimating model. This report is the third of a series of four that will result from the phase I of a four-phase study; Advanced System for Human Resources Support of Weapon System Development (Project 1959). The objective of Project 1959 is to demonstrate the technical feasibility of a method of reducing the cost of ownership of new weapon systems to the Air Force. The C-130E was selected as agreed upon with the Advanced Manned STOL Transport (AMST) System Program office as an appropriate system that may have value for the current AMST Program.

PROBLEM

The problem addressed in this task was to perform a historical life cycle cost analysis of the Air Force C-130E aircraft. The life cycle cost analysis of the Air Force C-130E aircraft. The life cycle period was defined as the past fifteen years (1962-1976), utilizing existing data that were collected and analyzed in the prior tasks. Reference AFHRL-TR-77-40, [1] and AFHRL-TR-77-48, [2] for the description and results of the prior tasks.

APPROACH

The approach to this task was to use the existing USAF Cost Analysis and Cost Estimating (CACE) model as outlined in AFR 173-10 [3], Cost Analysis - USAF Cost and Planning Factors, modified as necessary for this task and to utilize the historical data previously collected in prior tasks as described in references 1 and 2 above. Subtasks performed are:

- o Identify/structure LCC categories and elements by life cycle phases.
- o Compare identified LCC categories and elements with the USAF CACE model.
- o Develop required supplemental techniques and values.
- o Refine data inputs.
- o Develop modeling techniques.
- o Compute LCC outputs.
- o Perform LCC analysis.

[1] AFHRL-TR-77-40, C-130E Hercules Aircraft: Review of Published Literature and Structured Interviews, February 1977.

[2] AFHRL-TR-77-48, Historical Analysis of C-130E Resources, May 1977.

[3] AFR 173-10 , Cost Analysis - USAF Cost and Planning Factors, Department of the Air Force, 6 February 1975.

RESULTS AND CONCLUSIONS

The results of this study show that actual historical data, along with current existing cost estimating factors, can be utilized to approximate the historical life cycle costs (LCC) of existing Air Force in-service aircraft. Utilizing fifteen years of historical data, supplemented with planning factor value results where actual data were not acquired, the LCC for the major program phases covered are broken down as follows:

Life Cycle Phases	15 Year Total Cost (In Millions) 1976 $	Then Year $	Percent of Total 1976 $	Then Year $
1. R&D	3.221	2.257	.04	.05
2. Procurement/ Production	1257.358	838.54	17.01	18.02
3. Operations and Support	6134.742	3812.346	82.95	81.93
Total - - -	7395.321	4653.143	100	100

Cost figures and respective percentages are shown for both the base year of 1976 and the "then year" dollar. The major life cycle phases not included were conceptual and disposal. The average number of C-130E Aircraft reported by year in the Air Force inventory is the number of aircraft utilized for the annual operations and support cost computations. The average reported possessed aircraft on an annual basis was as follows:

1962 - 11	1967 - 291	1972 - 298
1963 - 83	1968 - 279	1973 - 293
1964 - 226	1969 - 289	1974 - 295
1965 - 315	1970 - 304	1975 - 296
1966 - 295	1971 - 323	1976 - 297

Estimating the historical LCC of an existing in-service aircraft is not an easy process. The major limiting factor is the accumulation of valid historical data. Some of the problems encountered in this area were as follows:

1. There is no one data repository/system that provides visibility into weapon system historical cost documentation.

2. It becomes necessary first to identify all of the various repositories and then select, collect and piece together the available information for each of the specific categories and elements.

3. The predominate USAF policy of retaining historical data for only short durations (6 to 24 months) has a profound effect on the ability to collect continuous historical cost information.

4. Existing cost estimating factors must be utilized in areas where actual data are not available and with no simple method of validating the factors.

Prior to 1975, there were no actual historical cost data collection systems in existence. In 1975, the Air Force implemented the Operational Support Cost Reporting (OSCR) system and the USAF Maintenance Cost System (MCS) which are both currently being developed. If continued, these systems will fill the major data voids in future years for weapon systems analysis. Both the OSCR and MCS programs are discussed in detail in AFHRL-TR-77-48, "Historical Analysis of C-130E Resources."

Because so many of the decisions which affect life cycle cost are made early in a new weapon system's life, the Air Force needs a cost data base containing the necessary information to adequately support those decisions. Such a data base could be developed for other systems containing information very similar to what has been collected and presented in this research effort on the C-130E aircraft. As a result of this study, it is clear that the actual life cycle cost of an Air Force operational system for a fifteen year period can be calculated. However the calculated LCC is only an approximation which will vary in terms of credibility dependent upon data repository information. In addition it requires a considerable investment in resources to compute this type of LCC. This is true whether Air Force planning factors or actual historical data are utilized in the life cycle cost analysis. This type of analysis should be used as part of the initial planning information in the conceptualization of the next generation weapon system. It provides a baseline from which to proceed in reducing LCC for the new system before attempting to avoid using the same high LCC items in the new system.

PREFACE

This report was prepared by the Boeing Aerospace Company, Logistics Support and Services (LS&S), Seattle, Washington, under USAF Contract F33615-76-C-0062. This contract was Phase I of Project 1959. Work was accomplished under the direction of the Advanced Systems Division of the Air Force Human Resources Laboratory, Air Force Systems Command with Major Duncan L. Dieterly as the Project Engineer.

Data emanating from Phase I (Work Unit 19590001), "Historical Analysis of C-130E Life Cycle Costs," are represented in a series of four reports. Data derived from this study effort, plus those emanating from the other tasks of this phase of Project 1959, will be weighed in terms of validity of sources along with an interpretation of the weighted evidence to indicate a methodology for analysis of the historical resource utilization of a system. Phase I provides a unique body of data, which for the first time, attempts to document the actual life cycle cost of a Weapon System.

Boeing Aerospace program technical leader was George R. Herrold. Principal program analysts were Frank D. Brown, Gary A. Walker and David H. Wilson. Boeing's contract report number is D180-19797-5. This approved technical report includes work performed from 29 June 1976 through 3 June 1977.

The Boeing Aerospace Company wishes to express their appreciation for the technical assistance and data provied by: 1) USAF Headquarters, Washington, D.C.; 2) Air Force Systems Command (AFSC), Andrews AFB, Maryland; 3) AFLC Headquarters, and Aeronautical Systems Division, Wright-Patterson AFB, Ohio; 4) Military Airlift Command, Scott AFB, Illinois; 5) all CONUS Aircraft Air Logistics Centers (e.g., San Antonio ALC, Warner Robins ALC, et al); 6) Air Training Command Headquarters, Randolph AFB, Texas; 7) Air Training Command, Sheppard AFB, Texas; 8) USAF Occupational Measurement Center, Lackland AFB, Texas; 9) Air Force Inspection and Safety Center, Norton AFB, California; 10) 62nd MAW Wing, McChord AFB, Washington; 11) 314th TAW, Little Rock AFB, Arkansas; and 12) 317th TAW, Pope AFB, North Carolina.

TABLE OF CONTENTS

TABLE OF CONTENTS
(Cont'd)

LIST OF ILLUSTRATIONS

LIST OF TABLES

I - INTRODUCTION

PURPOSE

The Air Force must be able to meet its specified mission requirements. To meet these requirements a spectrum of weapon systems must be designed, produced, maintained and operated. As the cost of sophisticated technology spirals upward, the Air Force planner must be able to maximize performance while minimizing cost. The crucial limiting parameter placed upon the weapon system spectrum is cost. Currently, it is popular to advocate different methods which provide the basis for controlling cost; such as cost of owrership and life cycle cost. All costing technologies have three aspects in common: the value of a weapon system is measured in dollars; the computation of the value is at a fixed point in time; and the function of costing the system is dependent upon the definition of variables to be included in the cost.

All too frequently, after a discrete set of variables has been agreed upon, as those that will generate the desired cost, it is determined that no information is available upon which to establish the dollar value of a variable; therefore the variable is excluded or treated as a constant. This is especially evident in those areas not directly associated with weapon system acquisition. This dilemma severely hampers the computation of the desired cost and reduces the probability of making the optimum decision. In order to redress the deficiency, the Advanced Systems Division of AFHRL has attempted to identify, develop and demonstrate a series of methods to allow for the inclusion of these variables in cost computations.

Through initial research efforts, it had been established that these variables could be quantified and included in cost analysis. During the same time frame it was realized that the final cost of a weapon system was dependent upon five major interacting factors:- (See Figure 1) a) system design, b) human resources, c) material resources, d) performance required, and e) operating of the system. In order to impact the cost of a system a change would be necessary in one of the factors; however, a change in any factor will have some impact on the others. Therefore, to adequately analyze the cost of a weapon system, a capability to model or simulate all five factors is necessary. As can be seen in the diagram, the life cycle cost of any weapon system is dependent upon the state of not only the design but the other factors. Any change in a factor will result in a new state and resultant LCC estimate. State "A" will result in a different LCC than state "B". Project 1959 "Advanced System for Human Resources Support of Weapon System Development," is the first effort to integrate these factors in a single analysis technique that could be used to evaluate the full ramifications of weapon system design, human resources, material resources, performance, and operations.

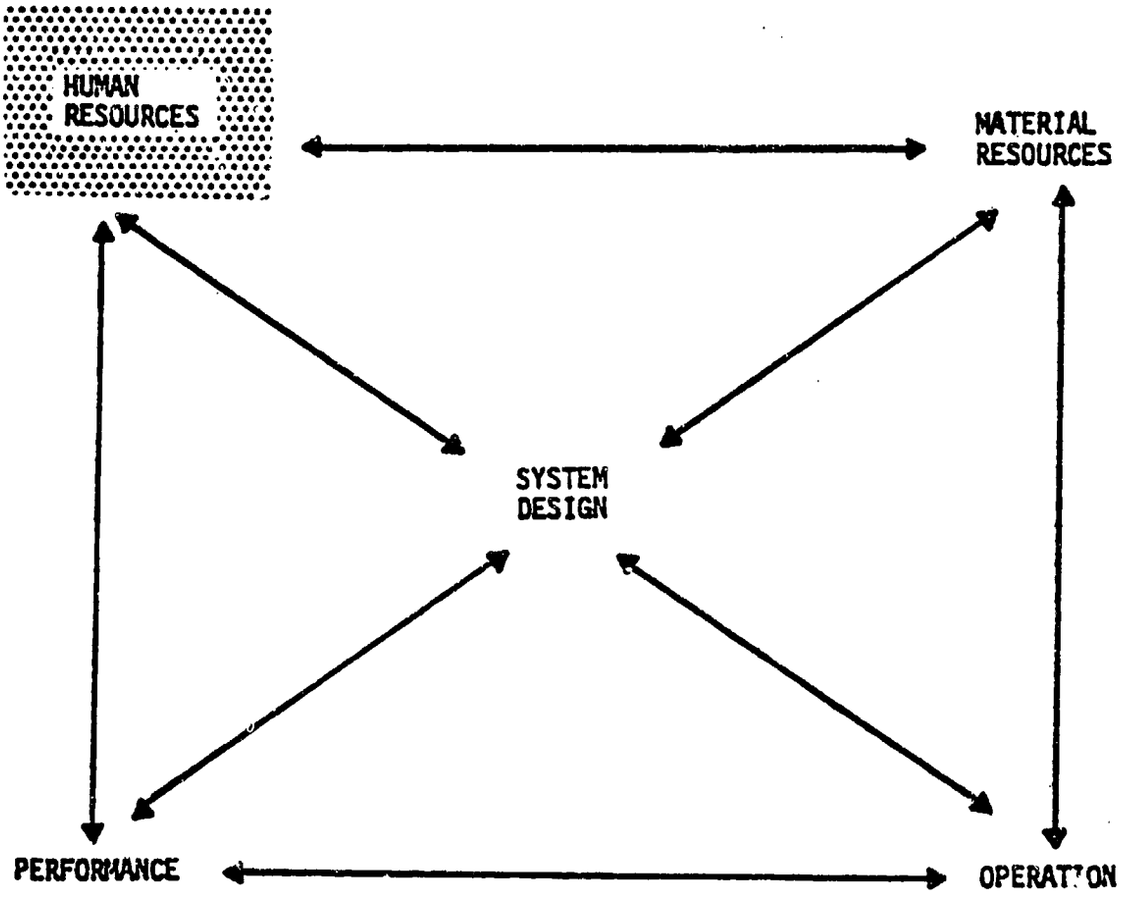

Figure 1 MAJOR INTERACTING FACTORS

PROJECT 1959 - PURPOSE AND GOALS

The purpose of Project 1959 is to demonstrate the technical feasibility of a method for reducing the cost of ownership to the Air Force of new weapon systems. The cost expended to maintain certain human resource configurations is a major contributor to Operations and Support costs. Consequently, programs aimed at the reduction of human resource parameter cost can have a significant impact on weapon system LCC.

In Project 1959, the Advanced Medium STOL Transport (AMST), being developed by the Air Force, will be the test case. Existing state-of-the-art technology in training, technical data, and manpower simulation techniques will be applied to demonstrating the potential for reducing the human resource support cost of the system. This project will provide for the inclusion of human resources parameter costs in engineering design studies, forecasting and controlling manpower requirements through the application of systems analysis and computer modeling techniques, improved technical data for maintenance personnel and early identification of training requirements and advanced training techniques appropriate for the new system. These techniques will be modified as required and integrated to provide a comprehensive approach to the development of a cost effective personnel support system for a new weapon system. As a demonstration, therefore, the techniques will only be applied to a seperate sub-system and not the total weapon system. The following four phases will be completed:

I. - Analysis of Resource Utilization of Present Operational System

This includes the gathering of data to indicate the level of human resources used in a similar past weapon system (the C-130E). Life cycle costing (LCC) is also included in the analysis.

II. - Integration and Application of Human Resource Technologies in Weapon System Design

In this phase five human resources technologies will be applied to the AMST. The technologies are human resources in design trade-offs, maintenance manpower modeling, job performance aids, instructional system design, and system ownership costing. The five main purposes of this effort to: (a) integrate the five human resource technologies, (b) demonstrate their coordinated application in a single weapon system development program, (c) determine the specifications for a consolidated data base serving five technologies, (d) demonstrate the consolidated data base, and (e) provide documentation for implementing these activities in future weapon system development programs.

III. - Maintenance Personnel Availability Analysis

This research will attempt to estimate the availability of human resources over time interfacing with AMST requirements data. Where discrepancies occur, alternate procedures will be indicated which will align human resources expected to be available with those required.

IV. - Personnel Sub-System Test, Evaluation, and Validation

This study will take the results of other studies and test, evaluate and validate them in the field.

This project is directed at reducing the personnel support cost of new systems. Research efforts under the project will demonstrate a technology for controlling the personnel, training, and manpower requirements of new systems without adversely affecting either operational readiness or system effectiveness. Application of this technology will lead to significant reductions in life cycle costs of new systems.

Although this effort will utilize a particular weapon system to demonstrate the technology for controlling personnel costs, this technology could be generalized to a wide spectrum of new systems being developed in the Air Force and other military services. In general the technology may be used for any type of new equipment being designed and developed for whatever purpose: military, government, or industrial.

HISTORICAL ANALYSIS OF C-130E LIFE CYCLE COSTS

The purpose of this effort is to establish a historical analysis of resource utilization of the C-130E Hercules. The analysis includes both human and material resource utilization as indicated from available records. In accomplishing this analysis a methodology was established which could be applied to the analysis of other weapon systems. This methodology includes type of information, possible sources, credibility of data, difficulty in reducing data and estimated resources required to perform the analysis. It was anticipated that most historical data would be lost because of the demand for current data to solve present problems without evaluating historical trends. In addition, large amounts of data may be available in such a form as to be prohibitive to collect and process for a computerized system.

Traditionally, when a weapon system is developing through the acquisition process, estimates are made as to the resources necessary to support that weapon system. After the system enters the Air Force inventory, the control of the human and material resources crosses several functions and commands. Seldom are the initial estimates verified or all resources controlled by one level of management. For example, the provisioning of spares becomes a prime concern of Air Force Logistics Command, while the manpower requirements are a major concern of the using Command. Therefore, once a weapon system is operational, no single point manager is responsible for the human and material support of that system. Multiple management generates a considerable amount of information and information systems to track and manage aspects of the weapon system. These sources of information are dispersed and in various configurations. To attempt to evaluate a system in terms of life cycle utilization or reduce that to a life cycle cost is a complex task. This phase of Project 1959 is designed to address this problem. Work was planned to be accomplished in six weeks.

DESCRIPTION OF TASKS

The sequence of the six major tasks suggested by the arrows in Figure 2 was actually flexible and dynamic. Much of the work, where appropriate, was performed in parallel.

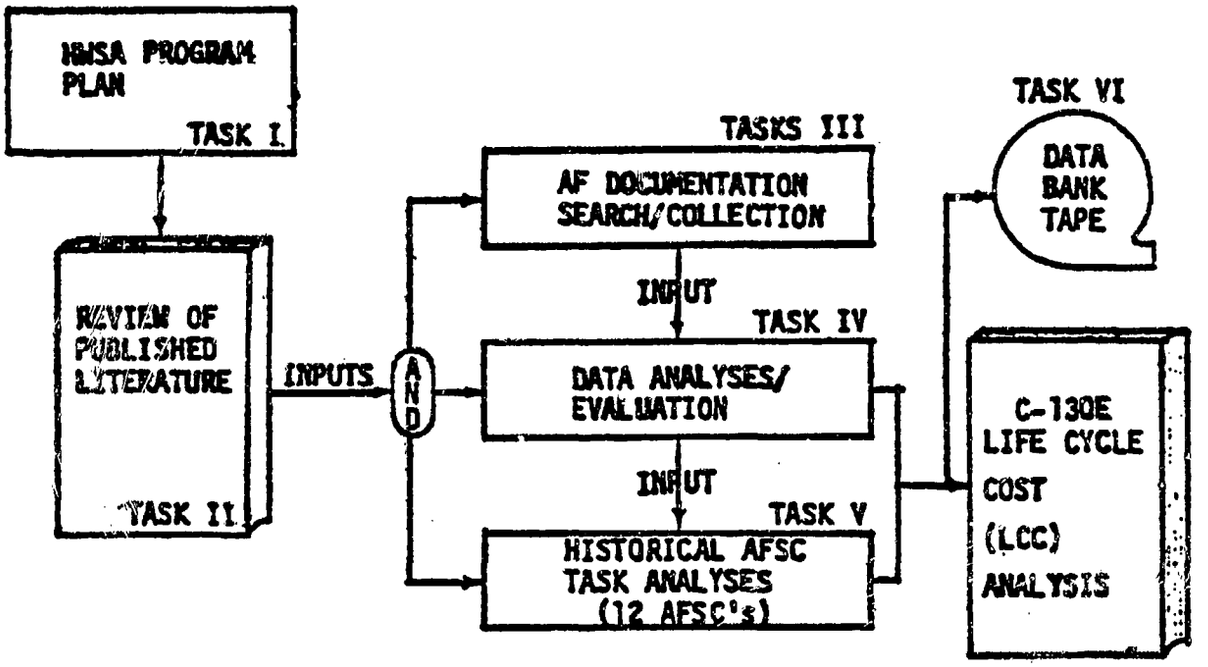

Figure 2 HISTORICAL WEAPON SYSTEMS ANALYSIS (HWSA) TASK FLOW DIAGRAM

Following is a brief overview of the actual work required by each of the six major tasks:

Task I Develop Contract Performance Plan

- Identify Data Sources and Agencies to be Contacted.
- Prepare Study Schedule and Milestones.
- Complete Contract Performance Plan.
- Kickoff Meeting.

Task II Historical Data Review

- Identify, Obtain and Analyze C-130 (C-130E Subset Where Possible) Research and Descriptive Studies Documentation.
- Conduct Structured Interviews.
- Publish Formal Technical Report.

Task III Air Force Documentation Search and Collection

- Identify and Screen Available C-130E Data Files.
- Obtain Applicable Experience Data.
- Catalog Data Files.

Task IV Data Analysis

Evaluate Data.
Develop Descriptive Statistical Summaries.
Publish Formal Technical Report.

Task V Historical Task Analysis

Select Skills for Task Analysis.
Identify Tasks for Each Skill.
Develop Task Parameters.

Task VI Life-Cycle Cost Analysis

Coordinate LCC Model Structure and Elements.
Perform LCC Analysis.
Generalize LCC Approach.
Publish Formal Technical Report.
Develop General Data Bank Computer Tape.

Task I was completed in August 1976 and Task II was completed in December 1976. Tasks III and IV were completed in April 1977 and Task V was completed in May 1977. Task VI was completed in June 1977 and is reported in this document. The final technical report contains a complete review of the entire study, and the historical task analysis (Task V) results.

GENERALIZED LIFE CYCLE COST METHODOLOGY

The results of this life cycle cost analysis research establish a methodology that could be utilized successfully on other Air Force weapon systems.

The approach and details as discussed in Section II consist of eight steps summarized as follows:

1. Identify cost categories and elements, within each life cycle phase to be considered, such as RDT&E, procurement, and operation and support costs.

2. Compare the identified cost categories and elements with the standard Air Force CACE model to isolate those categories and elements not included.

3. Develop supplemental techniques to cover the cost categories and elements not included in the standard model.

4. Refine historical data into proper input to satisfy model equations. In addition, for the values where historical data is not available, develop estimating factors or alternate techniques to establish data value.

5. Integrate the basic CACE model and supplemental techniques.

6. Compute the LCC estimates.

7. Analyze the LCC outputs.

8. Document the results.

As discussed in detail in other parts of this report, the major limiting factor to successfully perform historical life cycle cost analysis on an existing Air Force operational weapon system is the lack of a valid resource data base and/or system.

SUMMARY

This report is the third in a series of four reports to be completed under this phase of Project 1959. It describes the work accomplished during Task VI of a six-task study to historically analyze the resource utilization of the C-130E Hercules aircraft.

The approach was to perform a historical life cycle cost of the Air Force C-130E Hercules aircraft druing the past fifteen years. The historical resources (human and material) utilization data collected during prior Tasks provided the baseline information, and the Air Force Cost Analysis Cost Estimating (CACE) model, appropriately modified, was utilized for computing the C-130E life cycle cost for 15 years (1962-1976).

Results produced an estimated historical life cycle cost that includes: a) Research and Development, b) Procurement, and c) Operations and Support Costs of the Air Force C-130E aircraft for the years of 1962 through 1976 by year, in both 1976 and "then year" dollars.

The term "Life Cycle Cost" is defined as: "The total cost of a system over its full life. It includes the cost of Concepts; Research, Development, Test, and Evaluation (RDT&E); Procurement; Operations and Support; and where application, Phase Out or Follow-on." [4] Figure 3, "Weapon System Life Cycle Phases and Life Cycle Cost Major Categories," reflects a simple direct relationship between the different life cycle phases as described in AFSCP 800-3 [5], and the major cost categories, as discussed above. As a basis for establishing a structure for the associated life cycle cost concept, it was assumed that the C-130E weapon system consisted of the following major weapon system phases.

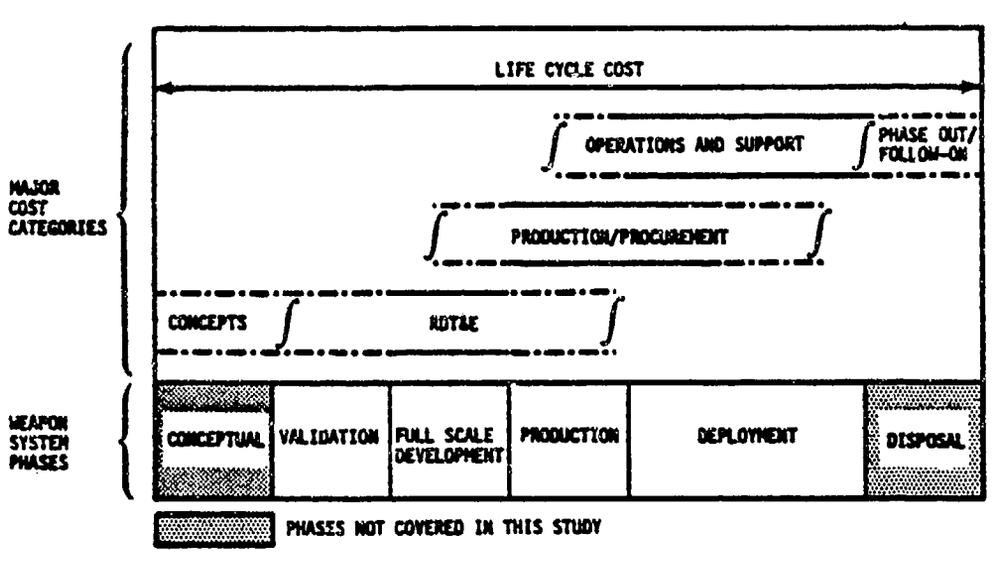

Figure 3 WEAPON SYSTEM LIFE CYCLE PHASES AND LIFE CYCLE COST MAJOR CATEGORIES

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[4] AFR 800-11, "Life Cycle Costing," 3 August 1973.

[5] AFSC Pamphlet 800-3, A Guide for Program Management, 9 April 1976.

Conceptual: This first phase in a system life cycle process is where technical requirements and economic baselines for a program acquisition process are established through comprehensive systems studies and experimental hardware development and evaluation. Conceptual stages overlap rather than occur sequentially; however, flowing from interacting inputs between the customer and program management, and identifying operational needs and technology, generally the following stages occur:

1. Identification and definition of conceptual systems.

2. Analysis of scenarios, feasibility, risk, cost, and trade offs.

3. Experimentation and test of operational requirements key components, critical subsystems and marginal technology.

Validation: This phase in a system life cycle process is where the major program characteristics (technical, cost and schedule) are validated through extensive analysis, trade off studies and hardware development. The objective is to validate the alternatives. It is normally preferred to rely on hardware development and evaluation rather than paper studies. Hardware development provides a better definition of program characteristics, higher confidence that risks have been minimized, higher confidence of a cost-effective system and a greater confidence in the ultimate outcome.

Full Scale Development: During the development phase, the system, including all of the items necessary for its support, is designed, fabricated, tested and evaluated. The intended result is a pre-production system that closely approximates the final product, that has been experimentally proven to satisfy specified requirements. Outputs are test results that: a) demonstrate and verify that the production product will meet stated requirements, and b) provide documentation necessary to support decisions for entering the production phase.

Production: During this stage, fabrication of the production configuration system of the selected design takes place. The weapon system, including training equipment, spares, etc., is produced for operational deployment. The principal objective of this phase is to produce and deliver to the operating command an effective and supportable system at minimum cost. The contract for production of the required quantities is made. Additional R&D for necessary system and component improvement is carried out. Estimations for initial spares requirements are made and special support and training equipment purchased.

Deployment: In this stage the weapon system is deployed and maintained for its primary mission. An important early activity of this phase is full test of the system. The command using the weapon system conducts Operational Test and Evaluation (OT&E) to determine its operational capability after the first operating unit has been delivered. In general, this stage lasts 15 years or more for major weapon systems. Operational costs include maintenance of support and training equipment, modifications, fuel, munitions, training, support personnel, spares procurement, and maintenance.

Disposal: Included in this phase is the removal, disposal, or conversion (through modifications) of the system to another mission function.

While the six major phases are somewhat artificial as to how major systems evolve, they nonetheless convey a chronological sequence that reasonably typifies the life (birth-to-death) cycle for a weapon system such as the C-130E Hercules aircraft. As shown in Figure 3 the conceptual and disposal phases were not considered within the scope of this effort in that data was unobtainable. The conceptual phase occurred long before the time period covered in this study and would be considered as sunk costs (past investments that cannot be captured) and the disposal phase is yet to occur on the C-130E aircraft. Therefore in this study the RDT&E, procurement, and operations and support cost categories constitute the historical life cycle cost estimate.

LCC TASK DESCRIPTION

The historical life cycle cost analysis of this study effort was accomplished as shown in Figure 4.

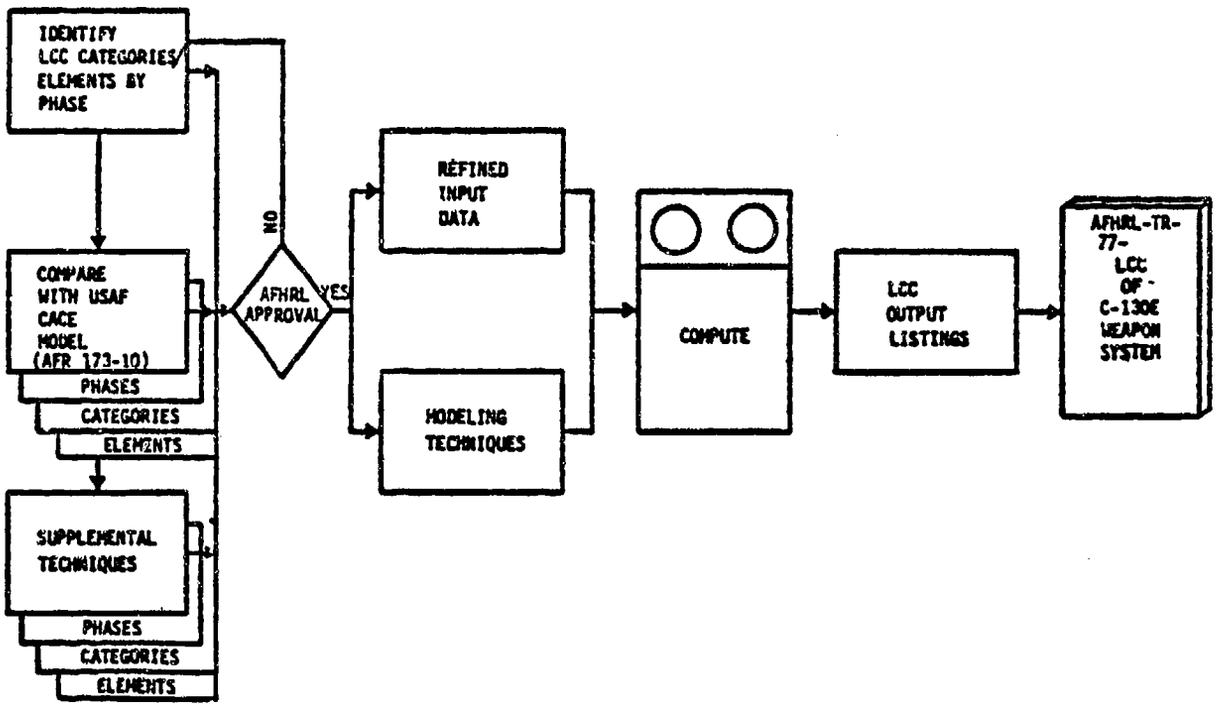

Figure 4. LIFE CYCLE COST ANALYSIS

CACE MODEL SELECTION

The Air Force standard Cost Analysis Cost Estimating (CACE) model was selected as the primary method, with adjustments, to be utilized for this life cycle cost analysis task. The CACE model computes steady state operating costs of a squadron of aircraft. Subsequently, the RDT&E and procurement costs had to be incorporated at an appropriate level manually.

CACE MODEL VERIFICATION

The particular version of the CACE model used was the basic model as outlined in AFR 173-10 which had been provided by the AMST System Program Office and was already programmed to run on Boeing computer equipment. The basic model was reviewed for adequacy as follows:

First - An initial stratification of cost elements desired for this study was identified, and

Second - These elements were compared with the basic CACE model to ensure that all categories and elements of cost were included or could be easily added either manually or by slight modifications to the basic model. Figure 5 reflects the initial stratification of cost elements. The comparison with the basic CACE model elements is as shown in Table A-1 of Appendix A. The operations and support categories were well covered by the CACE model; however, the support investment and acquisition categories were not included and had to be added.

One of the prime objectives of this study was gaining visibility into, and improving estimates of human resources operations and support costs impacts. Therefore, the basic CACE model, suitably modified, adequately satisfied the objective.

DEVELOP SUPPLEMENTAL TECHNIQUES

To capture and display the total C-130E elements of life cycle costs previously discussed, supplemental informational and model revisions were required. Additional dollar expenditures not captured by the model were in the areas of research and development, actual aircraft procurement, peculiar support equipment, and training devices. Each of these areas was handled on an individual basis with the by-year dollar expenditures, as acquired or derived, being added to the model results manually. The numerical results with discussion are covered in a later paragraph.

Since the model was designed as a Cost Analysis Cost Estimating (CACE) tool for life cycle cost exercises at an aircraft squadron level, and not fleet, as required in this task, amplifications were necessary.

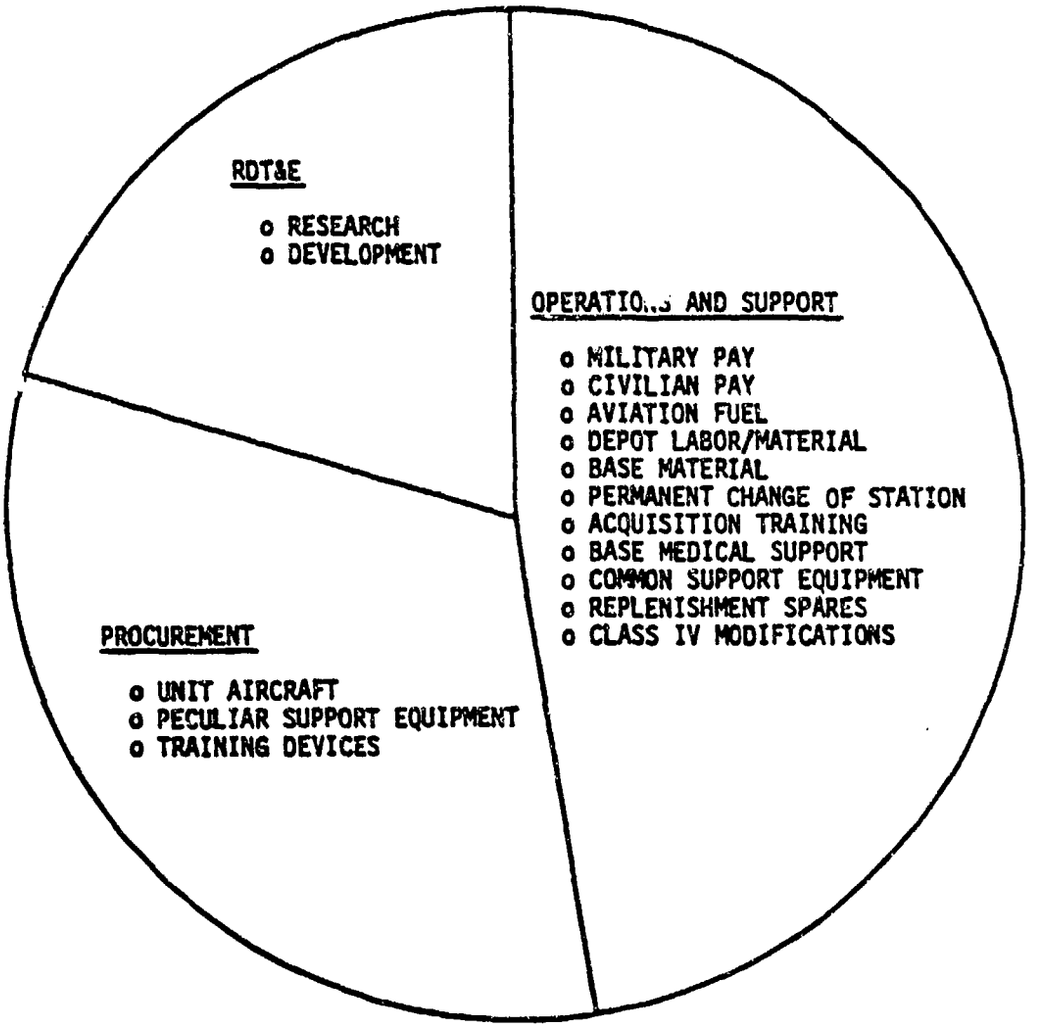

FIGURE 5 LIFE CYCLE COST CATEGORIES/ELEMENTS

The basic CACE model was expanded to determine total O&S cost for an aircraft fleet on a specified aircraft life, in years. Additional refinements included such amenities as geographic location inputs and data descriptions, various manpower inputs depending on data availability, and sub-routine requirements; the inclusion of a delivery schedule input table to cover 15 years; and model acceptance of annual aircraft deliveries for yearly computations.

COORDINATE MODEL STRUCTURE ELEMENTS

The basic Air Force CACE model with refinements was structured using existing formula elements. Test data files were then constructed using actual historical data where available. AFR 173-10 Cost Estimating Factors were used in those areas where actual data could not be obtained. The model was exercised successfully with the 15 year C-130E operations and support cost data. This basic CACE model structure along with the appropriate factors was provided to the AFHRL with a recommendation for adding the previously discussed supplemental costs manually to make up the system life cycle cost, and utilizing 1976 as the base year for the value of the dollar. In addition, to provide a scenario of the probable dollars expended by the Air Force to own and operate the C-130E, as well as portraying the erosion of the dollar buying power, each element was converted to "then year" dollars using the applicable standard DOD deflator factors. Figure 6 shows an overview of the cost categories by life cycle phase that are included/not included in this C-130 Life Cycle Cost Analysis.

COMPUTERIZED CACE (FLEET) MODEL TECHNIQUES

To fully implement and execute the CACE model, hereafter referred to as fleet model since it presents fleet values, specific sequential steps were necessary. Also, to most efficiently and effectively manipulate the model, an on-line remote terminal system, connected to an IBM 370 large scale computer, was used as opposed to batch processing. This immediate access and execution capability allowed variations in input table data and subsequent model results for analysis.

Two primary data input steps were utilized to execute the fleet model: a) Imbedding fixed constants within the program, and b) development of tables for call-up by the model at execution. Step two was the major method employed as it allowed greater flexibility to data input.

The first table developed, referred to as the delivery schedule, was the sequential monthly introduction of aircraft into the Air Force inventory as possessed aircraft. The source for these values was the Air Force Inventory and Status reporting system. This information presented a unique situation to model acceptance in that decreases of aircraft occurred occasionally giving a resultant negative monthly value. This variance in data was a result of the gain and loss reporting of the system.

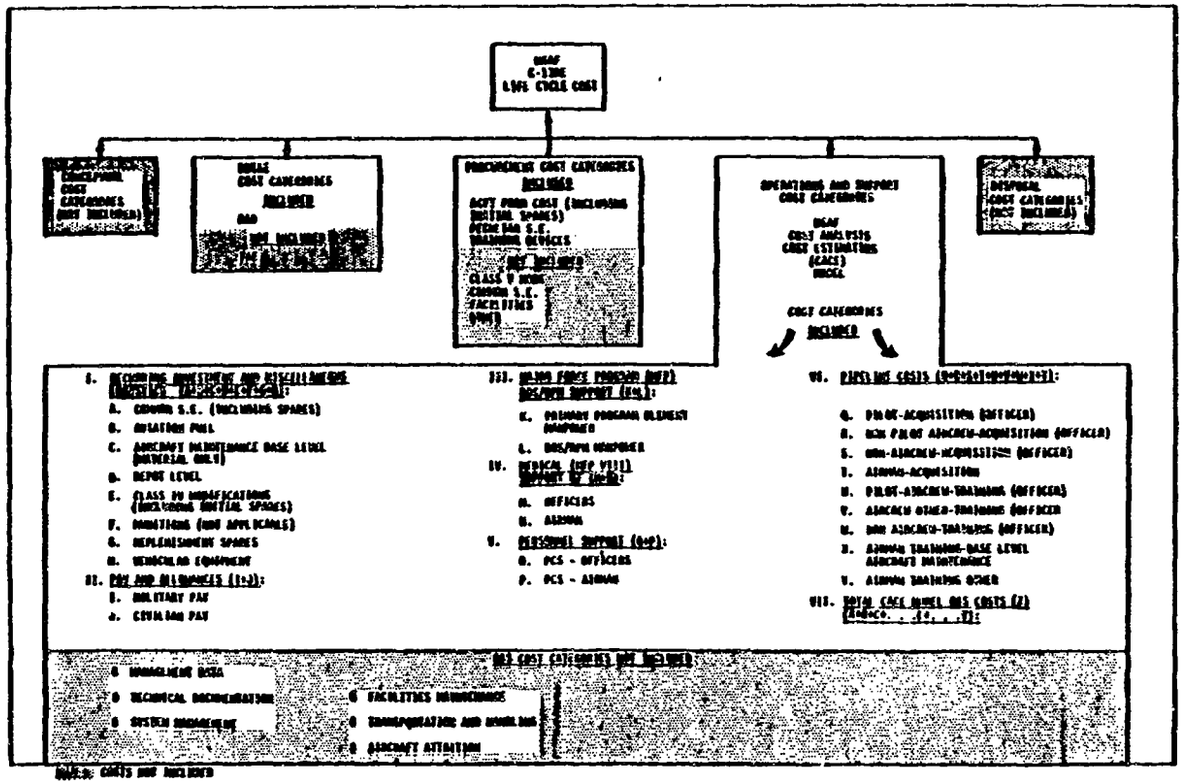

Figure 6 C-130E LIFE CYCLE COST CATEGORIES INCLUDED/NOT INCLUDED BY LIFE CYCLE PHASE

The second table was the actual model codes and respective values for the various formulas within the model. Three types of values made up this table: constants, variables, and location. Constant values remained fixed throughout program manipulations, variables changed with year or blocks or years, and location specified the geographical location. For purposes of this study, Continental United States, CONUS, was used throughout. The effects of these types of inputs on the results and the specific sub-routines within the model to handle them are covered in paragraphs under each specific applicable category.

DATA SOURCES AND LIMITATIONS

The information identified, collected, and analyzed in the earlier tasks was edited and screened for applicable data to satisfy the data element requirements for this life cycle cost analysis. The "Review of Published Literature" (see reference [1]) contains an extensive bibliography of obtained published literature on the C-130 Hercules aircraft and references to the various sources of that information. The "Historical Analysis of C-130E Resources" (see Reference [2]), contains a detailed evaluation of the Air Force C-130 documentation searched, collected, and evaluated. The evaluation consisted of three sub-tasks: 1) Development of a data evaluation matrix (Table B-1, Appendix B) that identifies the various information source(s) and evaluates the type of information available, 2) development of applicable techniques and actual computer processing of the data collected, and 3) statistical analyses and presentation of applicable information.

Table B-1 contains the results of analyzing and screening the data by elements into seven major categories; i.e.: 1) Operations, 2) Maintenance; 3) Reliability; 4) Safety; 5) Human Resources; 6) Material Resources, and 7) Cost. In addition, each major category is broken down into specific data elements and identifies: Source(s), Location, Type of Data, and Data Quantity/Quality.

A thorough search for USAF C-130E aircraft cost data was conducted covering the 15 years (1962-1976) of this study. All known available cost data repositories/systems were searched and screened for usable information to feed the life cycle cost analysis study task. During the data search, it became very clear that actual historical cost data have not been collected and maintained over the life cycle of the C-130E aircraft.

The principal sources of cost estimating data for the operations and support cost categories were: 1) The AFM 65-110 [6], 1-HAF-A1-110-12 Aircraft Inventory and Utilization Reports; 2) The actual operations and maintenance manpower data obtained from the operational units visited; and 3) The cost estimating factors contained in AFR 173-10 (see Reference 3). Table B-1, Appendix B, identifies the various data categories/elements and reflects the quantity and quality of data obtained.

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[6] AFM 65-110, Standard Aerospace Vehicle and Equipment Inventory, Status and Utilization Reporting, 1 October 1973.

The lack of valid historical cost data as discussed in the "Historical Analysis of C-130E Resources," (Reference [2]) was a major limiting factor in this analysis. During the attempt to accumulate C-130E historical cost data and/or other data required to generate costs, the following problems were encountered:

1. There is no one data repository/system that provides visibility into weapon system historical cost documentation.

2. It becomes necessary to first identify all of the various repositories and then to select, collect, and piece together the information from each for the specific category and data element.

3. Some data repositories do not have large mechanized systems and have only one document on file (usually hard copy). This results in a time-consuming effort for review and reproduction or frequently reduces or eliminates the possibility of acquiring needed information. Along these same lines, future study investigators will find data repositories that have copious documents, listings, reports that can be borrowed. Then they will require either laborious data extraction, or disassembly - reproduction - assembly and return to the home office which requires significant manhours for accomplishments. For example, the 1-HAF-A1-110-12 reports which make up a complete set of operations data had to be extracted from 180 monthly listings obtained from two different sources for the 15 year period.

4. The predominate USAF policy of retraining historical data for only short durations (6 to 24 months), or as in most cases (6 to 12 months) prior to purge, has had a profound effect on the ability to get continuous historical cost information.

5. RDT&E Cost - Research, Development, Test and Evaluation costs for the C-130E aircraft were non-existent within the applicable data repositories searched. The only C-130 RDT&E documented cost information available was located in T.O. 00-25-30 [7], including revisions back through the 1972 issue. T.O. 00-25-30 reflects prorated R&D costs for the C-130A, B, and D models only. The T.O. does not contain any R&D costs against the C-130E in the specfiic or prorated areas, and it is stated in the T.O. that: "Certain older systems may not include R&D costs due to nonavailability of information." In addition, most of the C-130 RDT&E expenditures were completed early in the C-130 development program, which was prior to the 1962 time period of this study. Consequently the R&D unit cost per aircraft of $5600 is the prorated R&D cost for C-130A, B, and D models (only), and it was assumed to be the same for the C-130E.

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[7] T.O. 00-25-30, Unit Costs of Aircraft, Guided Missiles, and Engines, 30 June 1975.

6. Aircraft Procurement Cost - Procurement costs for the Air Force C-130E aircraft were obtained from two different sources: a) ASD cost histories maintained at ASD/CSEH/HO, Wright-Patterson Air Force Base contained some documented procurement costs on the C-130E aircraft for the early initial production years (1961 through 1964), and b) aircraft procurement costs for later years (1968, 1969, 1970 and 1972) production aircraft were obtained from T.O. 00-25-30 using applicable revisions for each specific year. The number of production aircraft by year was determined by assuming the aircraft serial number to be the production year, and all aircraft with 1961 through 1964 serial numbers were reflected in the 1962 through 1965 time period because the first USAF C-130E possessed inventory aircraft was in 1962 and first flight of the C-130E was in April of 1962. The follow-on production aircraft were reflected in the actual year of the aircraft serial numbers. The C-130E average unit cost per aircraft over the 15 year time period (8 years of production aircraft) reflected $2.0 million which was assumed to be the aircraft unit cost and is broken down in the detail available as follows:

Average Unit Cost Per Aircraft	1962-1972 $ In Millions
Airframe	1.31
Propulsion	.48
Other Systems	.21
Total Aircraft - - - - - - -	$2.0 (Then Year)

The number of production aircraft (USAF procurement) was determined utilizing the serial numbers as discussed above for each year and results were as follows:

1961	15	1968	17
1962	83	1969	19
1963	143	1970	18
1964	96	1972	12

7. Other Procurement Cost - The ASD cost histories contained some C-130E peculiar support equipment and training devices costs for the 1962 through 1964 time period. In addition, the only other C-130E procurement cost that could be located was the class V modification costs as outlined in T.O. 00-25-30 starting with the 1972 issue.

HISTORICAL LIFE CYCLE COSTS - C-130E FLEET

The CACE model was initially developed to provide the cost analysis community with a vehicle having the flexibility to conduct research into new factor development and cost estimating techniques. It is this flexibility that has been amplified and refined to fit the LCC requirements of this task and present a historical 15-year profile of the C-130E Hercules aircraft. Basically this LCC is

achieved by not assembling costs via DOD appropriation budget codes but under a finite "building block" concept. Costs are built up/accumulated into major cost areas as follows: recurring investment and miscellaneous logistics; pay and allowances; base operating support and real property management support for major force program; medical; personnel support; and pipeline costs.

It was realized that the cost data used in this life cycle cost analysis would not be those used by designers and/or logisticians for assessing life cycle cost of specific subsystems or components, because the CACE model is not indentured down to that level of detail. The CACE model provides estimated O&S costs at the airplane (weapon system) level. However, this type of cost data could normally be used in most weapon system cost tradeoff issues and decisions occurring early in a new program development process, where the lack of actual data is limited. This is where the designer and/or logisticians can minimize the life cycle costs related to human and material resources utilization based on support structure policy decisions.

CACE FLEET MODEL EQUATIONS AND FACTORS

Each of the major areas in the CACE model is an accumulation of building blocks of definitive cost elements experssed as model relationships or equations. Table C-1, Appencix C, "CACE (Fleet) Model Equations and Factors," shows each of the major cost areas, specific building blocks, respective equations, type file, source, factor, and remarks. In addition, for ease in interpretation of the equations and their respective elements, Table C-2 presents each in numerical model code sequence. Each code descriptor, unit of measure, type file, and values used (constants/variables) is reflected.

LIFE CYCLE COST DISTRIBUTION BY YEAR (1962-1976)

The results of exercising the computerized CACE (Fleet) model for operations and support costs and manually adding the research, development, and procurement costs are shown in Table 1, "C-130E Fifteen Year Life Cycle Cost." Presentation of the twelve major operational and support categories reflected is the resultant logical grouping of the CACE fleet model elements (equations) as depicted in Table 1.

The life cycle cost results were all calculated and displayed by year, 1962 through 1976, in 1976 dollars. The standard Air Force yearly deflator factors for each category were then applied to show the "then year" dollar expenditure estimates. Yearly totals are shown for O&S and Research, Development and Procurement; 15 year totals for each category; along with grand totals for both types of dollars.

GROUND RULES AND ASSUMPTIONS

As with any presentation of expenditure figures, questions are imminent as to the ground rules and assumptions used. These guidelines and a discussion of the model sub-routines with respect to the applicable cost areas presented are covered in the following paragraphs.

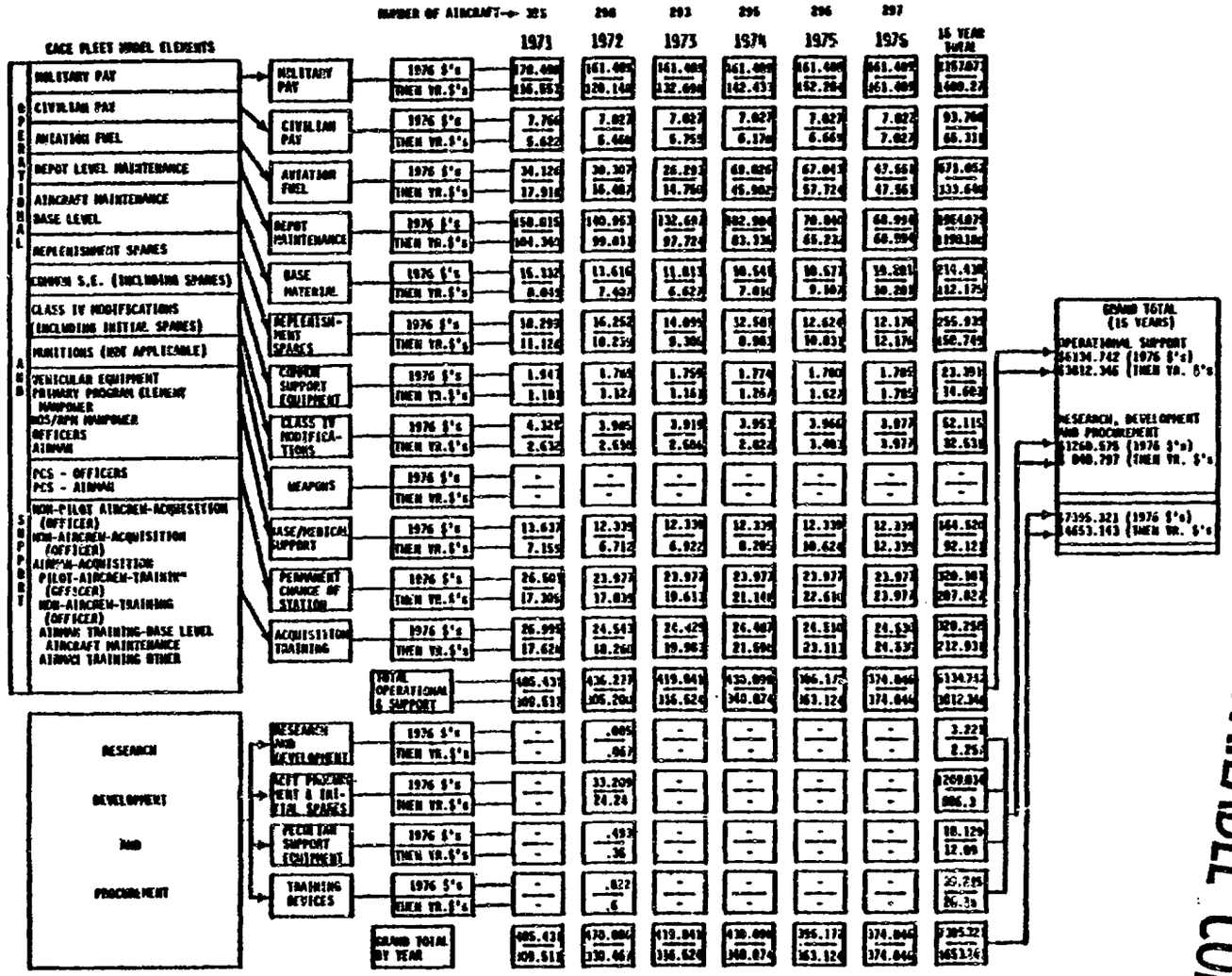
TABLE 1 C-130E FIFTEEN YEAR LIFE CYCLE COST

(ALL VALUES ARE $ IN MILLIONS USING 1976 BASE YEAR DOLLARS)

CASE FLEET MODEL ELEMENTS		NUMBER OF AIRCRAFT →	11	83	226	315	295	291	279	288	304
			1962	1963	1964	1965	1966	1967	1968	1969	1970
OPERATIONAL AND SUPPORT	MILITARY PAY	MILITARY PAY	1976 $'s	9.949	50.996	127.491	169.988	175.260	161.489	152.908	161.489	161.489
			THEN YR.$'s	3.730	19.327	52.144	72.245	81.145	79.614	79.248	88.815	98.993
	CIVILIAN PAY	CIVILIAN PAY	1976 $'s	.412	2.219	6.547	7.396	7.567	7.027	6.657	7.027	7.027
			THEN YR.$'s	.191	1.053	2.746	3.836	4.041	3.886	3.821	4.272	4.756
	AVIATION FUEL	AVIATION FUEL	1976 $'s	1.755	10.055	28.158	42.383	54.722	45.129	44.259	36.491	33.756
			THEN YR.$'s	.730	4.203	11.796	18.182	23.914	20.171	20.271	17.297	16.744
	DEPOT LEVEL MAINTENANCE AIRCRAFT MAINTENANCE BASE LEVEL	DEPOT MAINTENANCE	1976 $'s	7.573	45.448	126.856	189.492	230.290	197.650	168.672	142.552	165.139
			THEN YR.$'s	3.392	20.887	59.709	92.890	110.845	102.598	90.556	80.559	102.125
	REPLENISHMENT SPARES	BASE MATERIAL	1976 $'s	.092	5.110	14.310	21.539	27.584	22.740	19.169	15.823	15.167
			THEN YR.$'s	.371	2.136	5.996	9.290	12.054	10.367	8.788	7.495	7.523
	COMMON S.E. (INCLUDING SPARES)	REPLENISHMENT SPARES	1976 $'s	1.064	6.095	17.079	25.708	32.922	27.148	22.98	18.883	18.107
			THEN YR.$'s	.513	2.946	8.283	12.77	16.656	14.036	12.134	10.348	10.396
	CLASS IV MODIFICATIONS (INCLUDING INITIAL SPARES)	COMMON SUPPORT EQUIPMENT	1976 $'s	.051	.500	1.357	1.892	1.778	1.750	1.673	1.735	1.824
			THEN YR.$'s	.024	.242	.658	.942	.899	.905	.88	.951	1.047
	POSITIONS (NOT APPLICABLE)	CLASS IV MODIFICATIONS	1976 $'s	.113	1.114	3.024	4.222	3.956	3.899	3.77	3.866	4.065
			THEN YR.$'s	.054	.538	1.467	2.095	2.002	2.016	1.972	2.13	2.333
	VEHICULAR EQUIPMENT PRIMARY PROGRAM ELEMENT MANPOWER AOS/RPM MANPOWER OFFICERS AIRMAN	WEAPONS	1976 $'s	-	-	-	-	-	-	-	-	-
			THEN YR.$'s	-	-	-	-	-	-	-	-	-
	PCS - OFFICERS PCS - AIRMAN	BASE/MEDICAL SUPPORT	1976 $'s	.732	3.890	9.745	12.988	13.125	12.339	11.689	12.339	12.339
			THEN YR.$'s	.304	1.626	4.081	5.572	5.736	5.516	5.354	6.045	6.126
	NON-PILOT AIRCREW-ACQUISITION (OFFICER) NON-AIRCREW-ACQUISITION (OFFICER) AIRMAN-ACQUISITION PILOT-AIRCREW-TRAINING (OFFICER) AIRCREW OTHER-TRAINING (OFFICER) NON-AIRCREW-TRAINING (OFFICER) AIRMAN TRAINING-BASE LEVEL AIRCRAFT MAINTENANCE AIRMAN TRAINING OTHER	PERMANENT CHANGE OF STATION	1976 $'s	1.461	7.672	18.929	25.238	25.068	23.977	22.715	23.977	23.977
			THEN YR.$'s	.548	2.870	7.747	10.726	11.977	11.823	11.764	13.187	14.698
		ACQUISITION TRAINING	1976 $'s	1.431	7.499	19.164	25.082	28.209	24.39	23.168	24.39	24.681
			THEN YR.$'s	.537	2.842	7.836	11.000	13.068	12.024	12.001	13.385	15.125
		TOTAL OPERATIONAL & SUPPORT		25.433	148.506	371.650	526.732	607.279	527.544	477.641	448.516	467.564
				10.394	58.672	162.462	239.536	290.332	262.754	246.805	244.284	279.845
RESEARCH AND DEVELOPMENT AND PROCUREMENT		RESEARCH AND DEVELOPMENT	1976 $'s	.123	.579	1.153	.772	-	-	.132	.144	.132
			THEN YR.$'s	.084	.465	.803	.536	-	-	.095	.106	.101
		ACFT PROCUREMENT & INITIAL SPARES	1976 $'s	69.228	259.372	411.624	271.26	-	-	59.976	53.527	55.823
			THEN YR.$'s	45.6	170.98	271.7	180.48	-	-	40.8	36.06	35.44
		PECULIAR SUPPORT EQUIPMENT	1976 $'s	.683	3.773	6.499	4.329	-	-	.75	.824	.747
			THEN YR.$'s	.45	2.49	4.29	2.88	-	-	.51	.57	.54
		TRAINING DEVICES	1976 $'s	1.139	6.294	10.833	7.214	-	-	1.254	1.379	1.283
			THEN YR.$'s	.75	4.15	7.15	4.8	-	-	.85	.95	.9
		GRAND TOTAL BY YEAR		96.599	416.633	801.770	810.306	607.279	527.544	539.748	504.384	520.579
				57.278	236.762	446.402	428.204	290.332	262.754	289.065	282.775	337.934

TABLE 1 C-130E FIFTEEN YEAR LIFE CYCLE COST (Cont'd)

(ALL VALUES ARE $ IN MILLIONS USING 1976 BASE YEAR DOLLARS)



OPERATIONS AND SUPPORT COSTS

Military Pay: Determination of military pay was a direct computation using both actual acquired values for maintenance PPE officers and airmen and planning factors for the remaining types of personnel.

Civilian Pay: This pay was generated using actual data for maintenance and planning factors for the remaining areas. It should be noted this category covers base only and not depot. Depot labor is covered under the depot maintenance category.

Aviation Fuel: Planning factor of $289 per flying hour was utilized for 1976, and for prior years the actual planning factors ($/FH) were used for each specific year from available revisions to the planning factor guides. The ($/FH) factors ranged from ($78/FH) in 1962 to ($345/FH) in 1975. Each specific year value was then escalated to 1976 dollars for the model computation.

Depot Maintenance: Actual C-130 depot level labor and material dollar values obtained from AFLC RCS report: HAF-ACM(A)7109, "Depot Maintenance Cost Factors Report" for the years 1969 through 1975 were utilized. The dollar base values for 1962 through 1965 were assumed to be the same as 1969 and 1976 was assumed to be the same as 1975. The actual values were then escalated in 1976 dollars for each specific year using the appropriate escalation factor for labor and material respectively.

Base/Medical Support: Primarily this category consisted of the manpower calculation for use in the BOS/RPM support cost. The fleet model has the capability of computing these values one of four ways depending on the data availability. The model will compute total manpower if: a) the maintenance manhour per flying hour, or b) just the maintenance manpower, or c) each element is provided. Also, if only PPE manpower is provided, the model will compute BOS and medical costs for use in the total. This last methos was used in this task as actual PPE was known.

RESEARCH AND DEVELOPMENT COSTS

The research and development cost factor of $5600 per aircraft purchased, was utilized for the R&D category included in this study. RDT&E costs were nonexistent within the applicable data repositories searched. The only R&D costs that could be located were those contained in T.O. 00-25-30 (see Reference 7).

PROCUREMENT COSTS

Aircraft procurement: The aircraft procurement costs were acquired from two different sources: 1) ASD cost histories contained documented procurement costs for the early aircraft production years (1961-1964), including those costs for purchased peculiar support equipment and training devices; and 2) T.O. 00-25-30 was utilized for the 1968, 1969, 1970, and 1972 aircraft production years. The applicable revisions to the T.O. for each year were researched and the values for the corresponding

specific year were utilized. The number of production aircraft by year was determined by assuming the aircraft serial number to be the production year, and all aircraft with 1961 through 1964 serial numbers were reflected in the 1962 through 1965 time period because the first USAF C-130E inventory reported aircraft was in 1962 and the yearly inventories reported in 1962 through 1965 closely resembled the cumulative total of aircraft by serial number year of 1961 through 1964.

III - GENERAL DISCUSSION

This section describes the process and results of performing a historical life cycle cost analysis on the Air Force C-130E aircraft for the past fifteen years (1962-1976), utilizing existing data that were collected and analyzed in prior tasks. Reference AFHRL-TR-77-40, ▷ and AFHRL-TR-77-48, ▷ contain the description and results of these tasks.

The primary tool utilized was the existing Air Force CACE model modified and executed to a total fleet configuration via a remote terminal on-line system connected to a large scale IBM 370 computer. Normally the CACE model computes at a squadron level requiring manual computations to arrive at a fleet level. Of the three primary life cycle phases covered in this effort, the model computed and displayed the Operations and Support, whereas Research and Development (R&D), and Procurement/Production were determined and added manually. Dollar results in both 1976 and "then year" along with respective percentages are shown in Figure 7.

	Life Cycle Phases	15 Year Total Cost (In Millions) 1976 $	Then Year $	Percent of Total 1976 $	Then Year $
(1)	R&D	3.221	2.257	.04	.05
(2)	Procurement/ Production	1257.358	838.540	17.00	18.02
(3)	Operations and Support	6134.742	3812.346	82.95	81.93
	TOTAL	7395.321	4653.143	100	100

FIGURE 7 C-130E LIFE CYCLE COST BY PHASE

A detailed breakdown of these three phases into their respective categories and the percent each is of the total C-130E LCC is shown in Figure 8. The phase division category grouping in this figure was such that Research and Development stood alone, Procurement/Production encompassed aircraft procurement, peculiar support equipment, and training devices, with the remainder covered under Operations and Support. The top four dollar consumers, (military pay, depot maintenance, aircraft procurement, and aviation fuel) accounted for 80.5% of the total 15 year estimated expenditures. Since Operations and Support is by far the major phase, with over 82% of the total LCC cost, Figure 9 illustrates the percentages each category contributed to total Operations and Support. The major categories: military pay, depot maintenance (68% labor, 32% material), and aviation fuel accounted for over 77 percent. The percentage distributions shown in Figures 8 and 9 are applicable to both 1976 and "then year" dollars. Measured in dollars the values are significantly different, but the percentage difference is not significant.

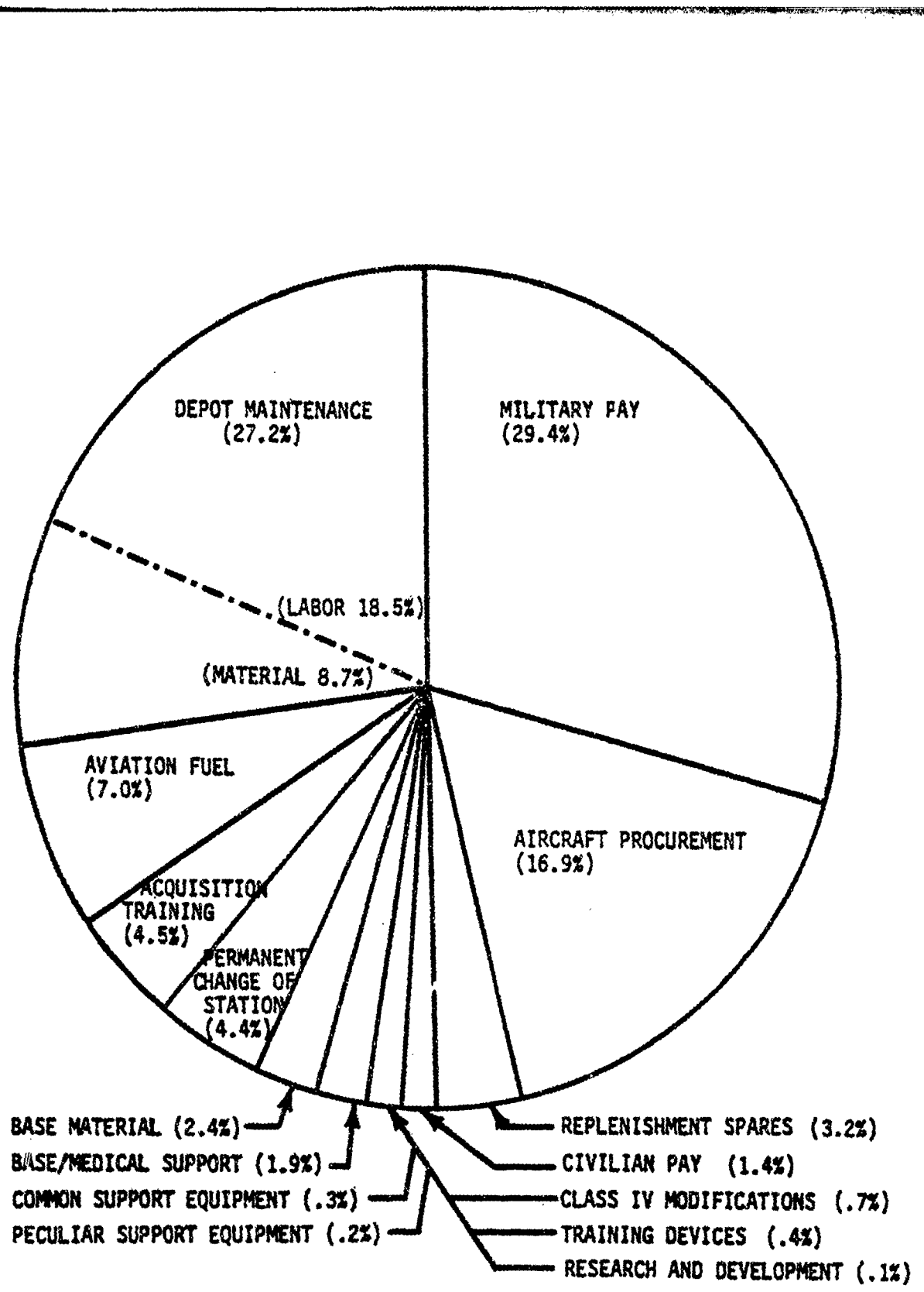


FIGURE 8 C-130E TOTAL 15 YEAR LIFE CYCLE COST BY MAJOR CATEGORY

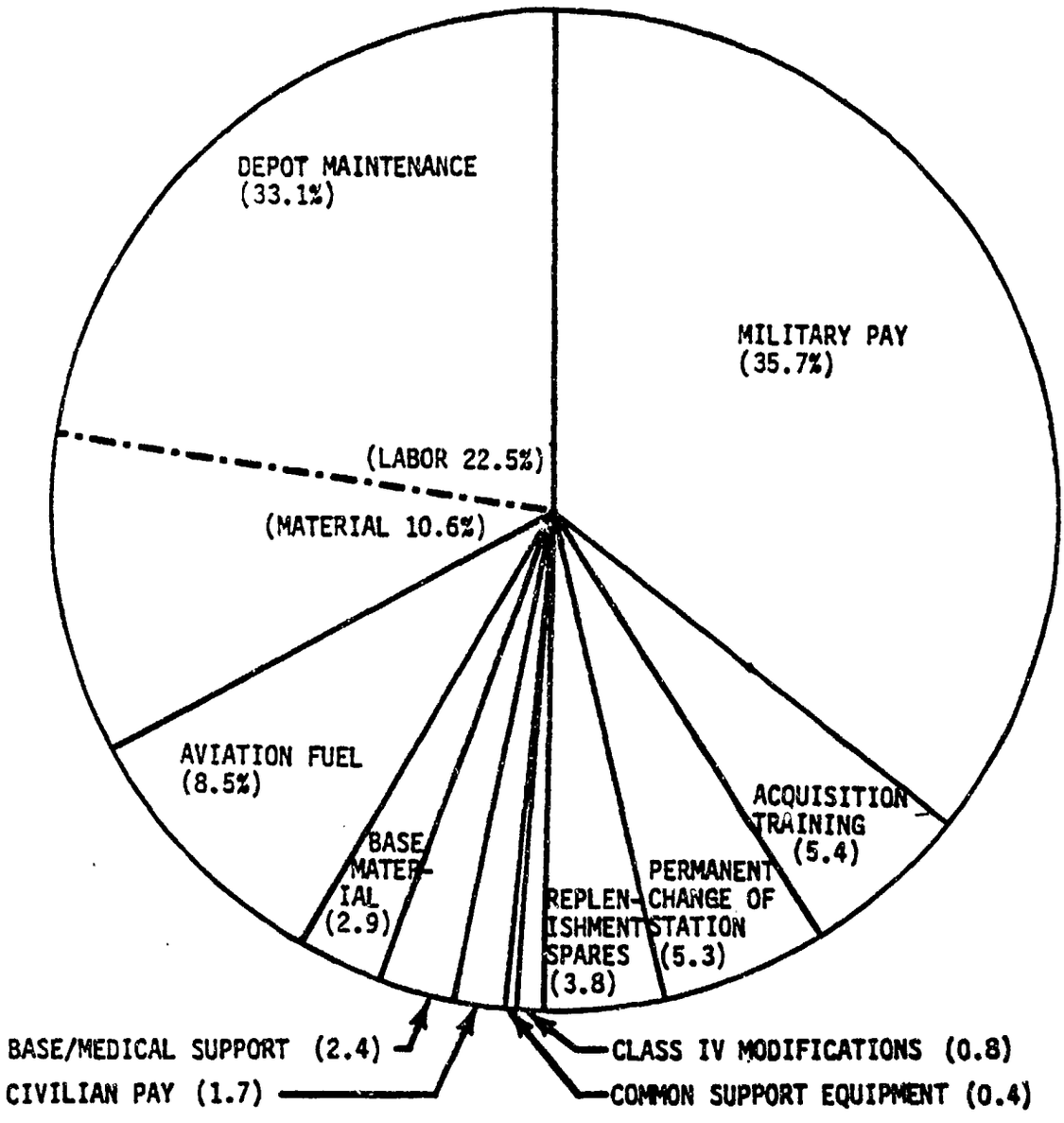


FIGURE 9 C-130E OPERATIONS AND SUPPORT 15 YEAR COSTS BY MAJOR CATEGORY

To vividly portray the affect of each Operations and Support category with respect to each other and how they varied with time, Figure 10 plots the respective cost values in 1976 dollars by year of operations. The impact of depot TCTO/modifications, the fuel crisis, and ever increasing personnel pay is clearly demonstrated in this figure.

Figures 11 and 12 depict the LCC costs for both 1976 base year dollars and "then year" dollars respectively versus the 15 years of operation. Although in 1976 base year dollars the general trend of experience is downward, as shown in Figure 11, in actuality the expenditure trend is increasing as shown in Figure 12. This trend is more vividly portrayed when Operations and Support costs and utilization is plotted against the 15 years of operation. This trend has added significance when viewed with the dramatic decrease in utilization shown in Figure 13. Further amplification of the cost increase is displayed in Figure 14 where the dollars per flying hour by year has been plotted. The most significant impact of the previsouly discussed major cost drivers; military pay, depot maintenance, and aviation fuel are shown in the rapidly increasing "then year" dollars per flying hour.

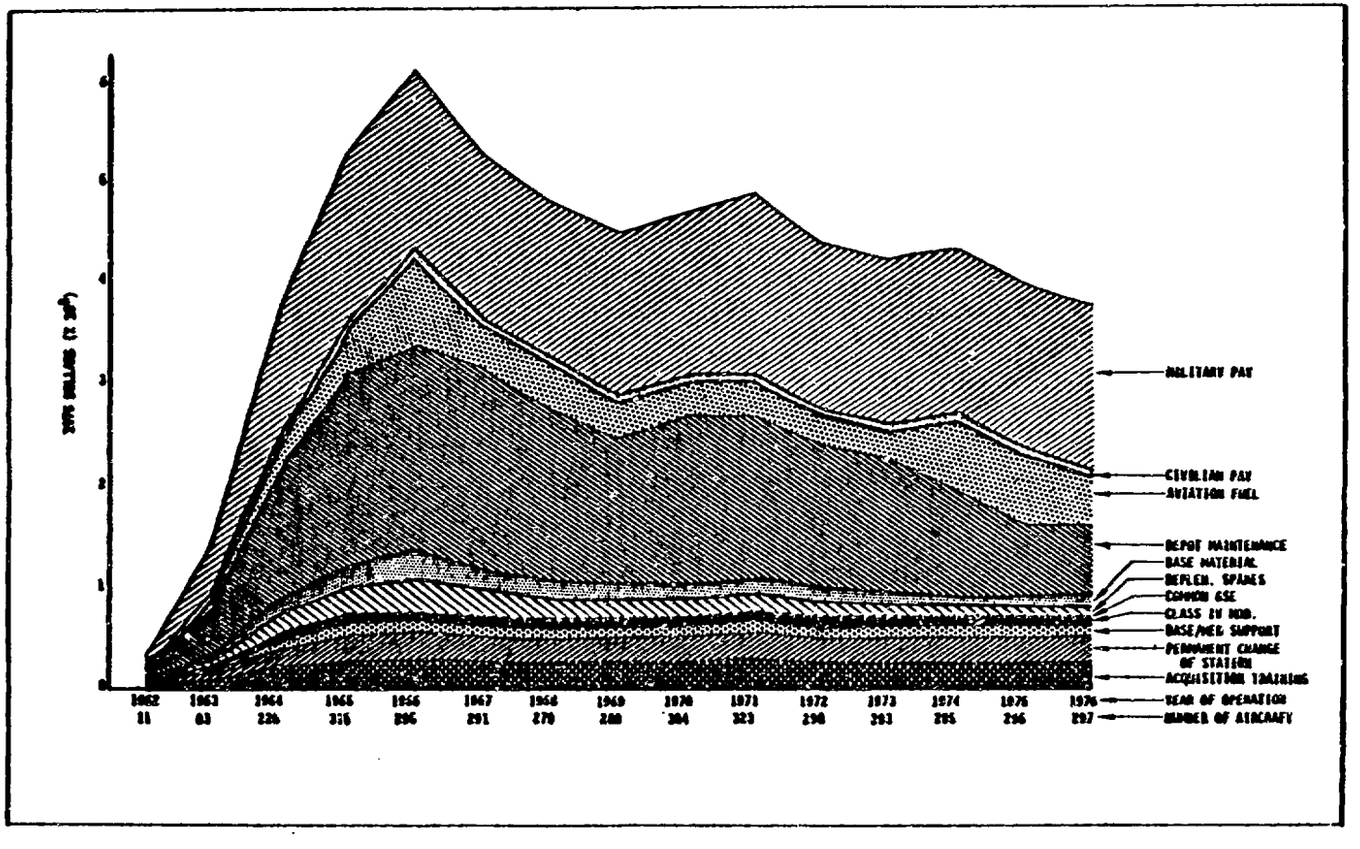


Figure 10 C-130E Cumulative Operational and Support Cost Elements By Year

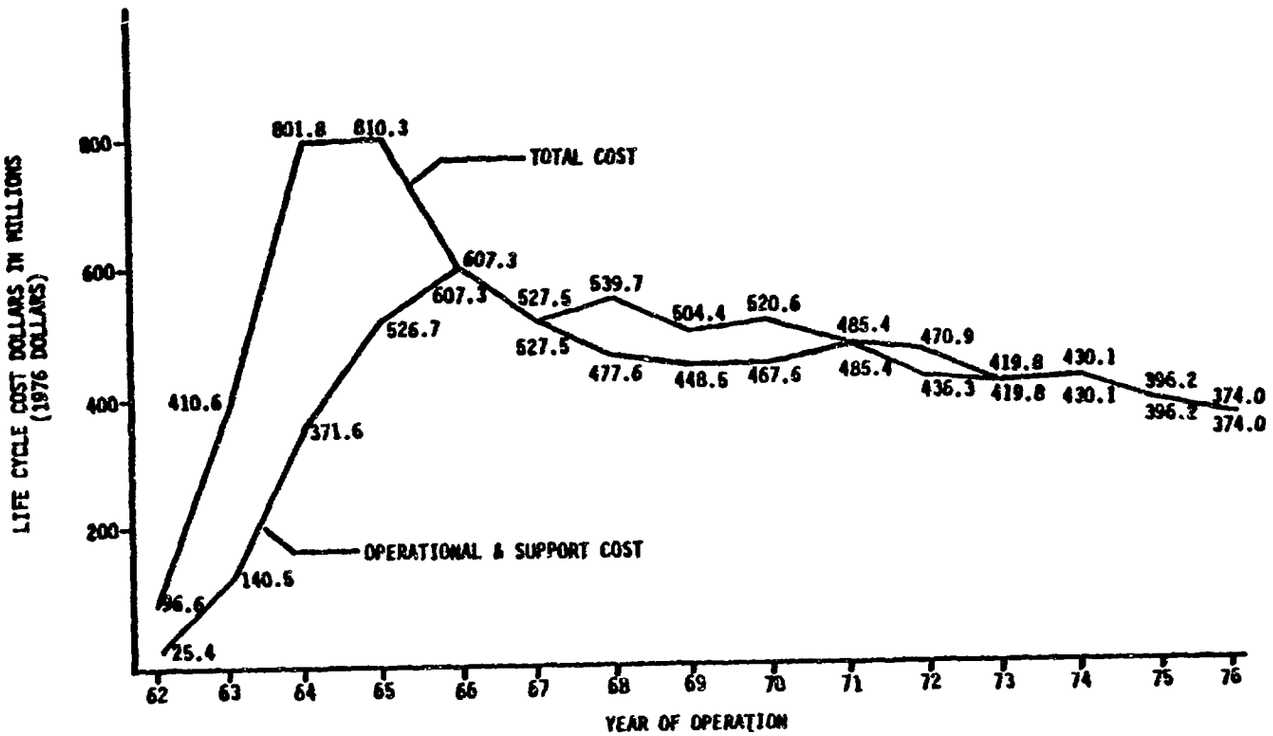


FIGURE 11 C-130E LIFE CYCLE COST DOLLARS VS YEAR OF OPERATION

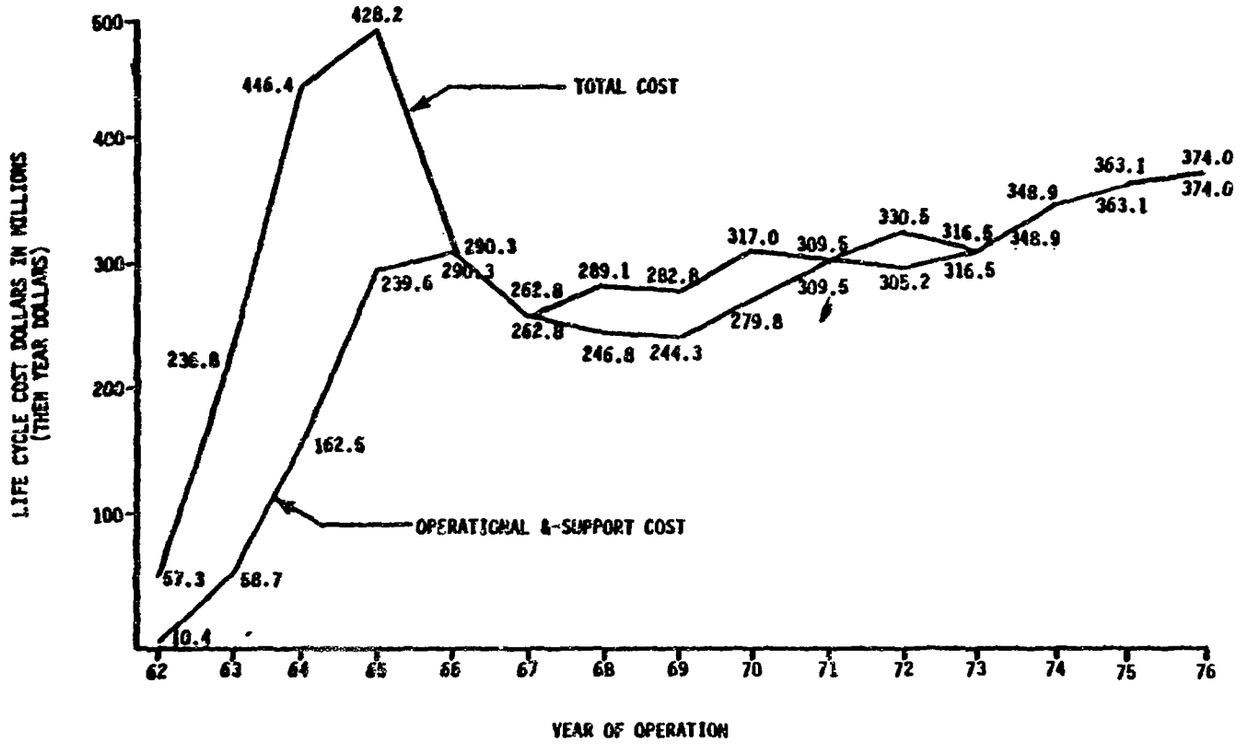


FIGURE 12 C-130E LIFE CYCLE COST DOLLARS VS YEAR OF OPERATION

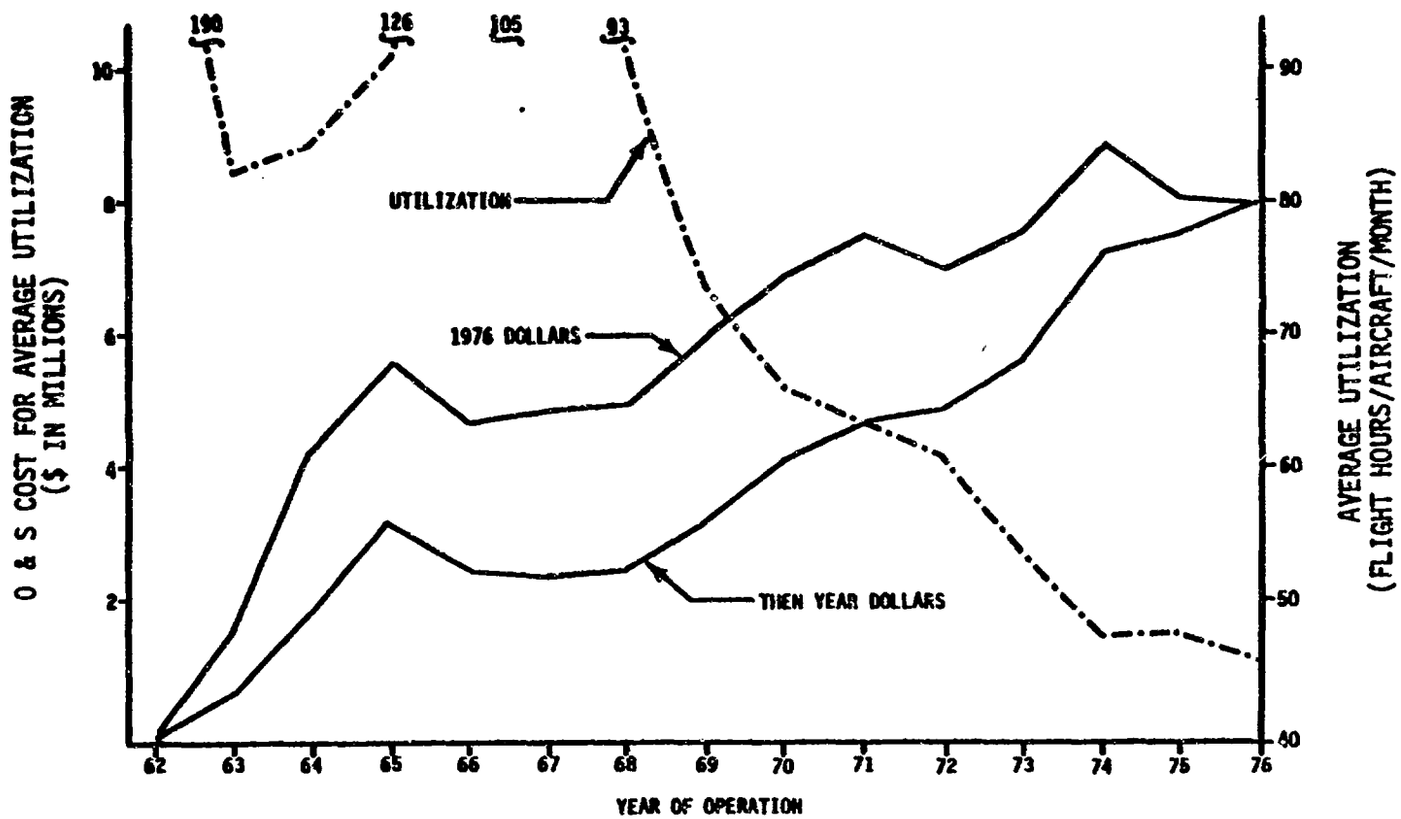


FIGURE 13 C-130E AIRCRAFT UTILIZATION VS. OPERATIONS AND SUPPORT COST FOR AVERAGE UTILIZATION BY YEAR OF OPERATION

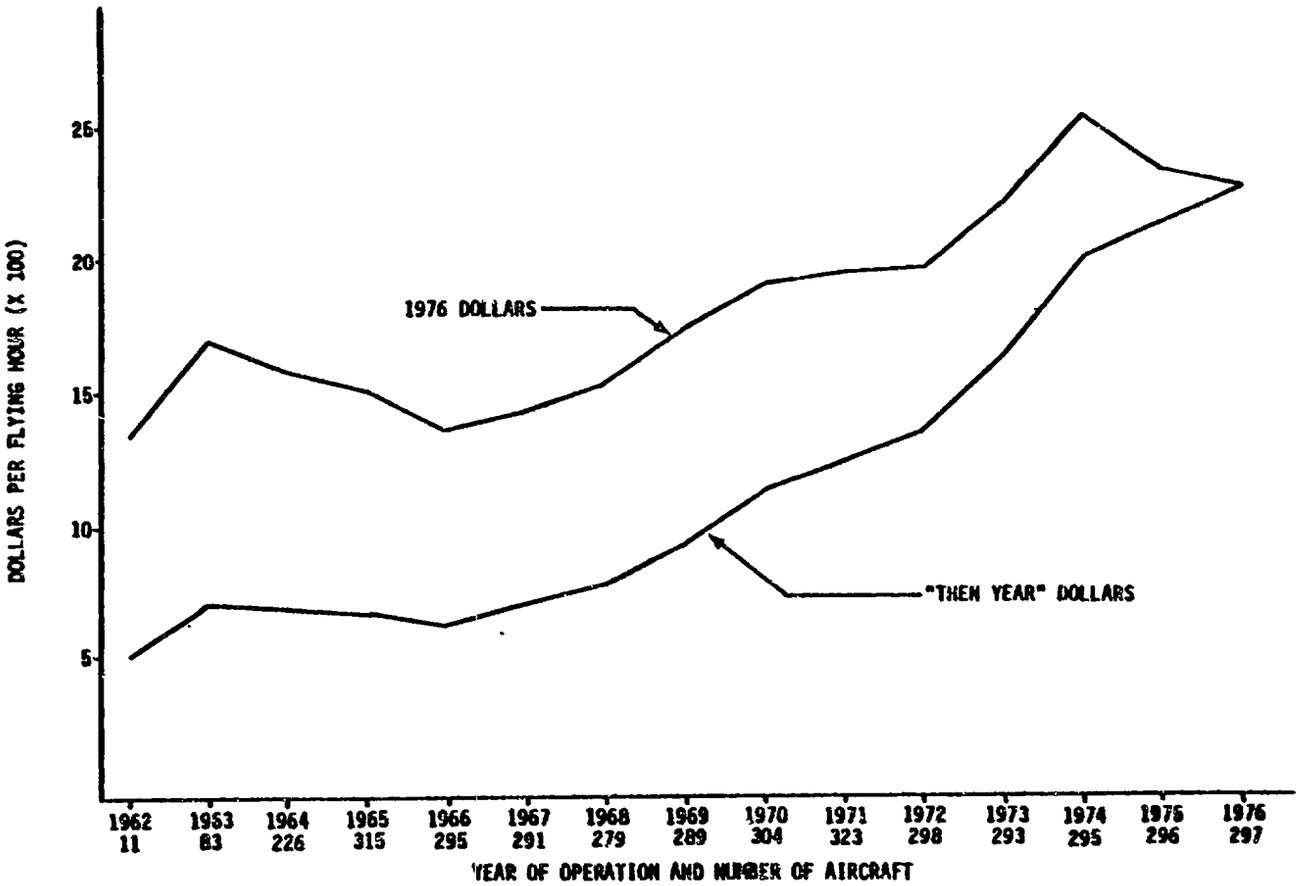


FIGURE 14 C-130E OPERATIONS AND SUPPORT COST PER FLYING HOURS BY YEAR

IV CONCLUSION

SYNOPSIS

This report describes the work accomplished under the final task, of a six task study to: "historically analyze the resource utilization profiles of the Air Force C-130E." The purpose of Task VI was to determine the historical life cycle cost of the C-130E over the past fifteen years (1962-1976), utilizing the data collected during the previous Tasks II thru V efforts and the current Air Force CACE model.

The objectives of Task VI were: a) to identify the required cost categories and elements in the various life cycle phases; b) compare identified cost categories with the CACE model, c) develop supplemental techniques for the phases and categories not covered by the CACE model, d) refine the necessary input data collected during previous tasks; and e) compute the fifteen year life cycle cost by year, using 1976 as the base year for dollars, and computing "then year" dollars utilizing the standard Air Force deflator factors, as applicable for each cost category.

Results of the work accomplished during this Task VI effort and included in this report are: a) the best estimate of fifteen year (1962-1976) life cycle cost of the Air Force C-130E aircraft that includes research and development costs, procurement costs, and operations and support costs, b) description of the procedures utilized to assemble the required historical input data and techniques, and) generalized methodology for performing historical life cycle cost analysis on other Air Force weapon systems.

PROBLEMS

- The general policy of USAF agencies to minimize historical data files, retaining data for short time periods only, as well as not having a central weapon system cost data repository had a profound affect on analytical results. Extrapolative and factored analytical results are always "second best" when attempting to evolve quantitative weapon system cost histories.

- In some cases, data requested were either not delivered or made available or sometimes arrived too late for analysis. This precluded quantitative compilation of meaningful, accurate historical profiles for some cost categories.

- Considerable difficulty was encountered in sorting C-130E data from gross data on the C-130 MDS. This was especially true in the research and development and procurement cost categories, along with several of the operations and support cost categories such as: depot costs and base level material consumption costs.

- Conflicting sources of data (the number of procured versus reported possessed C-130E aircraft per year from 1962-1976), obviated or attenuated analytical progress. In some cases these conflicts could not be satisfactorily resolved.

- Compilation of fragmented and/or discontinuous data resulted in formulation of some scattered, discontinuous historical cost analysis results.

Most of the difficulties encountered were resolved through extensive conference telephone conversations with key personnel located within the multitude of USAF agencies visited by Boeing investigators. Data source summaries, compiled during field trips, served as an excellant "yellow page" directory for additional follow-up when conflicts or other difficulties were encountered. Conflicting data problems were primarily resolved via engineering judgment or by direct contact with the originating USAF agency(ies).

RECOMMENDATIONS

- The Air Force should develop and implement an integrated historical data repository to accumulate and maintain the categories of data, by weapon system, required to perform historical life cycle cost analysis on existing systems, and for assisting in accomplishing cost trade studies during new weapon system development programs. Such a data repository would be beneficial in identifying system life cycle cost drivers and implementing necessary improvements.

- In the interium, until the ultimate historical data repository can be developed, additional data bases of historical life cycle cost on other selected Air Force weapon systems should be developed in a manner similar to that accomplished in this study on the C-130E aircraft.

- Nineteen of the 27 CACE model formulae deal directly with human resource categories (e.g., military pay, civilian pay, permanent change of station (PCS) costs, etc.). Further, 60.5% of the C-130E total life cycle cost by major category is directly attributable to human resources. It matters little from a cost standpoint if hardware reliability is improved several times if related manpower attenuator changes are not made. Concept and design innovations included in new systems to improve hardware utilization, must be accompanied by related changes in the human support needs. It is recommended that the real cost drivers in weapon systems be ranked in order of most to least costly and that this rank order serve as the priority upon which future Air Force weapon system decisions are based.

LIST OF REFERENCES

1. AFHRL-TR-77-40, C-130E Hercules Aircraft: Review of Published Literature and Structured Interviews, February 1977.

2. AFHRL-TR-77-48, Historical Analysis of C-130E Resources, May 1977.

3. AFR 173-10, Cost Analyses - USAF Cost and Planning Factors, Department of the Air Force, 6 February 1975.

4. AFR 800-11, Life Cycle Costing, 3 August 1973.

5. AFSC Pamphlet 800-3, A Guide for Program Management, 9 April 1976.

6. AFM 65-110, Standard Aerospace Vehicle and Equipment Inventory, Status and Utilization Reporting, 1 October 1973.

7. T.O. 00-25-30, Unit Costs of Aircraft, Guided Missiles, and Engines, 30 June 1975.

GLOSSARY OF ABBREVIATIONS

AMST	ADVANCED MEDIUM STOL TRANSPORT
AFR	AIR FORCE REGULATION
AFHRL	AIR FORCE HUMAN RESOURCES LABORATORY
AFLC	AIR FORCE LOGISTICS COMMAND
AFSC	AIR FORCE SYSTEMS COMMAND
AFB	AIR FORCE BASE
ALC	AIR LOGISTIC CENTER
AF	AIR FORCE
AFM	AIR FORCE MANUAL
ADP	AUTOMATIC DATA PROCESSING
ASD	AERONAUTICAL SYSTEMS DIVISION
AFCT	AIRCRAFT
AGE	AEROSPACE GROUND EQUIPMENT
AMN	AIRMAN
AMY	AIRMAN MAN YEAR
BLIS	BASE LEVEL INFORMATION SYSTEM
BOS	BASE OPERATING SYSTEM
CACE	COST ANALYSIS AND COST ESTIMATING
CR	CREW RATIO
DOD	DEPARTMENT OF DEFENSE
DM	DEPOT MAINTENANCE
FH	FLIGHT HOUR
FAC	FACTOR
HWSA	HISTORICAL WEAPON SYSTEM ANALYSIS
HQ	HEADQUARTERS
IL&S	LOGISTICS SUPPORT AND SERVICES
IBM	INTERNATIONAL BUSINESS MACHINE
LCC	LIFE CYCLE COST
MAW	MILITARY AIRLIFT WING
MDC	MAINTENANCE DATA COLLECTION
MOD	MODIFICATION
MDS	MODEL/DESIGN/SERIES
MY	MAN YEAR
MMY	MARGINAL MAN YEAR
MED	MEDICAL
NR	NUMBER
OT&E	OPERATIONAL TEST AND EVALUATION
OMY	OFFICER MAN YEAR
OS	OVERSEAS
O&S	OPERATIONS AND SUPPORT

GLOSSARY OF ABBREVIATIONS (Cont.)

POL	PETROLEUM, OIL AND LUBRICANTS
PCS	PERMANENT CHANGE OF STATION
PPE	PRIMARY PROGRAM ELEMENT
P&A	PAY AND ALLOWANCES
RDT&E	RESEARCH, DEVELOPMENT, TEST AND EVALUATION
R&D	RESEARCH AND DEVELOPMENT
RPM	REAL PROPERTY MAINTENANCE
REP	REPLENISHMENT
S.E.	SUPPORT EQUIPMENT
SQD	SQUADRON
STOL	SHORT TAKEOFF AND LANDING
TR	TECHNICAL REPORT
TAW	TACTICAL AIRLIFT WING
T&E	TEST AND EVALUATION
T.O.	TECHNICAL ORDER
USAF	UNITED STATES AIR FORCE
UE	UNIT EQUIPMENT
UR	UTILIZATION RATE
UPT	UNDER PILOT TRAINING
WRM	WAR READINESS MATERIAL
YR	YEAR

APPENDIX A

COMPARISON OF THE INITIAL STRATIFICATION OF COST ELEMENTS WITH AIR FORCE CACE MODEL

Table A-1 INITIAL STRATIFICATION OF COST ELEMENTS

Cost Elements	Elements Included In Basic CACE Model
I. Operations and Recurring Support	Yes
A. Logistics Support	Yes
1. Maintenance Manpower	Yes
a. Organization	Yes
b. Intermediate	Yes
c. Depot	Yes
2. Maintenance Material	
a. Organization	Yes
b. Intermediate	Yes
c. Depot	Yes
3. Systems Management	No
4. Second Destination Transportation	No
5. Technical Documentation Update	No
6. Replacement of Reparable Spares	Yes
7. Recurring Modifications	Yes
8. Replacement of Common Support Equipment	Yes
9. ADP Software Modifications	No
B. Unit Operations	Yes
1. Manpower	Yes
a. Combat Command Staff	Yes
b. Aircrew	Yes
c. Munitions	N/A
2. Aviation POL	Yes
C. Unit Operating Support	Yes
1. Unit Services Manpower	Yes
2. Security	Yes
3. Miscellaneous Support	Yes

Table A-1 INITIAL STRATIFICATION OF COST ELEMENTS (continued)

Cost Elements	Elements Included In Basic CACE Model
D. Personnel Support	
1. Recruit/Technical Training Manpower	Yes
a. General	Yes
b. Peculiar	No
2. Permanent Change of Stations (PCS)	Yes
3. Medical Manpower	Yes
4. Medical Materiel	Yes
5. Miscellaneous Personnel	Yes
6. Undergrad Pilot/Navigation Training	Yes
II. Support Investment	
A. Initial Provisioning	No
1. Reparable Spares	No
2. Consumable Material	No
3. War Readiness Material (WRM)	N/A
B. Support Equipment	
1. Peculiar	No
a. Organization	No
b. Intermediate	No
c. Depot	No
2. Common	No
a. Organization	No
b. Intermediate	No
c. Depot	No
C. Documentation	No
D. Facilities (Includes Utilities)	No

Table A-1 INITIAL STRATIFICATION OF COST ELEMENTS (continued)

Cost Elements	Elements Included In Basic CACE Model
E. Training	No
1. Devices	No
2. Facilities	No
3. Courses, etc.	No
F. ADP Software	No
III. Acquisition	No
A. RDT&E	No
B. System Investment (Non-Recurring)	No
1. Unit Aircraft	No
2. Modifications	No
3. Training Equipment	No
4. Peculiar Support Equipment	No
5. Other	No

APPENDIX B

DATA EVALUATION MATRIX

TABLE B-1 DATA EVALUATION MATRIX

CATEGORY/ELEMENTS OF DATA	SOURCES/AGENCY	LOCATION	TYPE OF DATA OR DATA FILE	DATA QUANTITY/QUALITY			
				FORM(S)	RECORDS	YEARS	REMARKS
1. OPERATIONS DATA:							
AIRCRAFT UTILIZATION DATA AS FOLLOWS:	AFLC/MO	WPAFB, OHIO	AFM 65-110 (1-HAF-A1-110-12)	HARD COPY	1700	1962-1969	96 MONTHLY REPORTS CONTAINING ALL USAF AIRCRAFT REQUIRED MANUAL EXTRACTION
- NO. OF AIRCRAFT	AFLC/LOAC	WPAFB, OHIO	AFM 65-110 (1-HAF-A1-110-12)	HARD COPY	1900	1970-TO-DATE	84 MONTHLY REPORTS CONTAINING ALL USAF AIRCRAFT REQUIRED MANUAL EXTRACTION
- TOTAL FLIGHT TIME (BY MDS/MONTH)							"
- AIRCRAFT UTILIZATION (FH/ACFT/MO)							"
- TOTAL SORTIES							"
- AVERAGE MISSION LENGTH							"
- TOTAL LANDINGS							"
- NORM RATE							"
- NORS RATE							"
- OR RATE							"
AIRCRAFT ABORTS:							"
- OPERATIONS	-	-	-	-	-	-	NOT OBTAINED
- MAINTENANCE	AFLC/ACWHP	WPAFB, OHIO	D056 SERIES REPORTS	TAPE	5,989,175	1971-1976	DATA NEED TO BE REFINED TO ELIMINATE DUPLICATE ABORTS REPORTED BY WORK UNIT CODE
- OTHER	-	-	-	-	-	-	NOT OBTAINED
TURN AROUND TIME	-	-	-	-	-	-	NOT OBTAINED
2. MAINTENANCE DATA:							
SYSTEM-MAINTENANCE MANHOURS (ORGANIZATIONAL/INTERMEDIATE) BY YEAR	AFLC/ACWHP	WPAFB, OHIO	D056 SERIES REPORTS	TAPE	5,989,175	1971-1976	DATA WERE PROVIDED IN NORMAL AFM 66-1 BASIC RECORD FORMAT AND REQUIRED USE OF IN-HOUSE PROGRAMS PROCESSING TO ENABLE ADEQUATE DATA CONFIGURATION FOR ANALYSIS
GENERAL SUPPORT MAINTENANCE MANHOURS (WORK UNIT CODES 01 THRU 09)	C-130E UNITS						
	62 MAW	MCCHORD AFB, WA	AFM 66-1 MDC/BLIS	LISTING	-	1976	COMPLETE GENERAL SUPPORT DATA MUST BE OBTAINED FROM EACH INDIVIDUAL UNIT AND THE UNITS CURRENTLY MAINTAIN 12 MONTHS OF HISTORY
	314 TAW	LITTLE ROCK AFB, AR	AFM 66-1 MDC/BLIS	LISTING	-	1976	
	317 TAW	POPE AFB, NC	AFM 66-1 MDC/BLIS	LISTING	-	1976	

TABLE B-1 DATA EVALUATION MATRIX (Cont'd)

CATEGORY/ELEMENTS OF DATA	SOURCES/AGENCY	LOCATION	TYPE OF DATA OR DATA FILE	DATA QUANTITY/QUALITY			
				FORM(S)	RECORDS	YEARS	REMARKS
T.O. MAINTENANCE MAN-HOURS	WRALC/MMMSS	WARNER ROBINS AFB GA	D047 SERIES REPORTS	LISTING	21,000	1962-1976	DATA WERE PROVIDED IN BASIC RECORD FORMAT BY AIRCRAFT TAIL NUMBER AND REQUIRED DEVELOPMENT OF IN-HOUSE PROGRAMS TO ENABLE ADEQUATE DATA CONFIGURATION FOR ANALYSIS
PERCENT MAINTENANCE MAN-HOURS FOR: SCHEDULED MAINT. UNSCHEDULED MAINT. SERVICING BENCH CHECK TROUBLESHOOTING OTHER	AFLC/ACVMP	WPAFB, OHIO	D056 SERIES REPORTS	TAPE	5,989,175	1971-1976	DATA WERE PROVIDED IN NORMAL AFM 66-1 BASIC RECORD FORMAT AND REQUIRED IN-HOUSE PROGRAMS/ PROCESSING TO ENABLE ADEQUATE DATA CONFIGURATION FOR ANALYSIS
SYSTEM MAINTENANCE TASKS (ORGANIZATIONAL/INTERMEDIATE) BY YEAR	AFLC/ACVMP	WPAFB, OHIO	D056 SERIES REPORTS	TAPE	5,989,175	1971-1976	DATA WERE PROVIDED IN NORMAL AFM 66-1 BASIC RECORD FORMAT AND REQUIRED USE OF IN-HOUSE PROGRAMS/ PROCESSING TO ENABLE ADEQUATE DATA CONFIGURATION FOR ANALYSIS
3. RELIABILITY DATA:							
TOTAL FAILURES BY SYSTEM BY YEAR	AFLC/ACVMP	WPAFB, OHIO	D056 SERIES REPORTS	TAPE	5,989,175	1971-1976	DATA WERE PROVIDED IN NORMAL AFM 66-1 BASIC RECORD FORMAT AND REQUIRED USE OF IN-HOUSE PROGRAMS/ PROCESSING TO ENABLE ADEQUATE DATA CONFIGURATION FOR ANALYSIS
PERCENT FAILURES a. BEFORE FLIGHT b. IN-FLIGHT c. BETWEEN FLIGHT d. DURING INSPECTION	AFLC/ACVMP	WPAFB, OHIO	D056 SERIES REPORTS	TAPE	5,989,175	1971-1976	DATA WERE PROVIDED IN NORMAL AFM 66-1 BASIC RECORD FORMAT AND REQUIRED USE OF IN-HOUSE PROGRAMS/ PROCESSING TO ENABLE ADEQUATE DATA CONFIGURATION FOR ANALYSIS
REPAIR DATA (BASE) a. ORGANIZATIONAL b. INTERMEDIATE - BENCH CHECK - SRTS - CONDEMNED							
REPAIR DATA (DEPOT)	AFLC/ACVRC	WPAFB, OHIO	D041 CREATE DATA H036B DMIF PROD. COST D087 I&S GROUPING DATA	TAPE	125,000	FY 1975-1976	DATA FROM EACH DATA SYSTEM WERE PROVIDED ON INDIVIDUAL TAPES AND REQUIRED USE OF IN HOUSE PROGRAMS/PROCESSING.
4. SAFETY DATA - ACCIDENTS MAJOR MINOR - INCIDENTS	AIR FORCE SAFETY CENTER (IG/SER)	NORTON AFB, CA	ACCIDENT/INCIDENT REPORTS	LISTINGS		1962-1976	ACCIDENT SUMMARY REPORTS FOR 1962-1976 AND INCIDENT REPORTS FOR 1976 WERE PROVIDED.

TABLE B-1 DATA EVALUATION MATRIX (Cont'd)

CATEGORY/ELEMENTS OF DATA	SOURCES/AGENCY	LOCATION	TYPE OF DATA OR DATA FILE	DATA QUANTITY/AVAILITY			
				FORM(S)	RECORDS	YEARS	REMARKS
5. HUMAN RESOURCES DATA: MANPOWER AUTHORIZED VS ASSIGNED BY AFSC - AFSC - LEVEL - GRADE - YEARS EXPERIENCE - TRAINING REQUIREMENTS EXPERIENCE - EDUCATION	C-135E UNITS 62 MAW 314 TAW 317 TAW	MCCHORD AFB, WA LITTLE ROCK AFB, AR POPE AFB, NC	AUTHORIZED: UNIT DETAIL LISTINGS	LISTING	-	CURRENT	CURRENT MDL'S PROVIDED THE AUTHORIZED MANPOWER BY FUNCTIONAL AREA
			ASSIGNED: MAINTENANCE: MONTHLY MAINTENANCE DIGESTS-MCS: MAC-LGX (M)7103	DOCUMENT	-	1976	THE MONTHLY/MAINTENANCE DIGESTS PROVIDED ASSIGNED MAINTENANCE MANPOWER BY WORK CENTER FOR THE MAINTENANCE ORGANIZATIONS
			OPERATIONS	-	-	CURRENT	CREW RATIO PER UE WAS OBTAINED FROM OPERATIONS
			OTHER	-	-	-	NOT OBTAINED
	MILITARY PERSONNEL CENTER (MPC)/XPSRT	RANDOLPH AFB, TX	MANPOWER ASSIGNED BY: COMMAND/AFSC/GRADE YEARS EXPERIENCE TRAINING EXPERIENCE EDUCATION	- - - -	- - - -	- - - -	THE MILITARY PERSONNEL CENTER HAS A HISTORY FILE OF THIS TYPE DATA COVERING (1971-CURRENT). HOWEVER THE DATA WERE NOT PROVIDED FOR THIS RESEARCH TASK BECAUSE EDP PROCESSING WAS COST PROHIBITIVE
	HQ USAF/ACMCA	WASHINGTON, D.C.	ESTIMATING AND PLANNING FACTORS/AFR 173-10	DOCUMENT	-	CURRENT	PROVIDES OPERATING AND SUPPORT COST ESTIMATING AND PLANNING FACTORS FOR USAF WEAPON SYSTEMS, TO INCLUDE VARIOUS HUMAN RESOURCE DATA/FACTORS
6. MATERIAL RESOURCES: - MATERIAL CONSUMPTION - GROUND SUPPORT EQUIPMENT - TRAINING EQUIPMENT - OTHER	HQ USAF/ACMCA	WASHINGTON, D.C.	ESTIMATING AND PLANNING FACTORS/AFR 173-10	DOCUMENT	-	CURRENT	PROVIDES OPERATING AND SUPPORT COSTS ESTIMATING AND PLANNING FACTORS FOR USAF WEAPON SYSTEMS TO INCLUDE AGE, POL, MAINTENANCE-AIRCRAFT (BASE AND DEPOT LEVEL), AND CLASS IV (INCL. INITIAL SPARES), REPLENISHMENT SPARES AND VEHICULAR EQUIPMENT COSTS

TABLE B-1 DATA EVALUATION MATRIX (Cont'd)

CATEGORY/ELEMENTS OF DATA	SOURCES/AGENCY	LOCATION	TYPE OF DATA OR DATA FILE	DATA QUANTITY/QUALITY			
				FORM(S)	RECORDS	YEARS	REMARKS
6. MATERIAL RESOURCES (CONT.	HQ USAF/ACMCA	WASHINGTON, D.C.	OPERATING AND SUPPORT COST REPORT (OSCR)	LISTING	-	FY 1975	PROVIDES C-130E OPERATING AND SUPPORT COST BY VARIOUS COST CATEGORIES. THIS SYSTEM WAS IMPLEMENTED WITH FY 1975. FY 76 INFORMATION NOT RELEASED AS OF THE PRINTING OF THIS DOCUMENT
	C-130E UNITS 62 MAW 314 TAW 317 TAW	MCCHORD AFB, WA LITTLE ROCK, AR POPE AFB, NC	MAINTENANCE COST SYSTEM (MCS) EXECUTIVE MANAGEMENT SUMMARIES (REF AFM 177-380)	MONTHLY REPORTS	-	JUL'75-DEC'76	PROVIDES WEAPON SYSTEM DIRECT AND INDIRECT MATERIAL COSTS BY MONTH AT BASE LEVEL. IDENTIFIES VALUE OF MATERIAL CONSUMED WITHIN WBS WITHIN MDS/NON MDS BY MONTH. MDS CATEGORIES INCLUDE AIRCRAFT, AIRFRAME, ENGINE, ACCESSORIES, ELECTRONICS, NON MDS INCLUDES SUPPLY SUPPORT, CEM, AGE AND OTHER CATEGORIES
	FUEL OFFICES C-130E UNITS 62 MAW 314 TAW 317 TAW	 MCCHORD AFB, WA LITTLE ROCK AFB, AR POPE AFB, NC	POL (FUEL) CONSUMPTION DATA		-	1976	PROVIDED NUMBER OF GALLONS OF FUEL C-130's CONSUMED EACH MONTH OF 1976
7. COST DATA: - RDT&E - PROCUREMENT - OPERATIONS & SUPPORT	HQ USAF/ACMCA	WASHINGTON, D.C.	ESTIMATING AND PLANNING FACTORS/AFR 173-10	DOCUMENT	-	CURRENT	PROVIDES OPERATIONS AND SUPPORT COST ESTIMATING AND PLANNING FACTORS FOR USAF WEAPON SYSTEMS
	HQ USAF/ACMCA	WASHINGTON, D.C.	OPERATING AND SUPPORT COST REPORT (OSCR)	LISTING	-	FY 1975	PROVIDES C-130E OPERATIONS AND SUPPORT COST BY VARIOUS COST CATEGORIES. THIS SYSTEM WAS IMPLEMENTED WITH FY 1975. FY 1976 INFORMATION WAS NOT RELEASED AS OF THE PRINTING OF THIS DOCUMENT.
	AFLC/ACM	WPAFB, OHIO	UNIT COSTS OF AIRCRAFT T.O. 00-25-30	TECHNICAL ORDER	-	CURRENT	PROVIDES AVERAGE AIRCRAFT UNIT FLYAWAY COST, BASED ON FUNDING APPROPRIATIONS.

TABLE B-1 DATA EVALUATION MATRIX (Cont'd)

CATEGORY/ELEMENTS OF DATA	SOURCES/AGENCY	LOCATION	TYPE OF DATA OR DATA FILE	DATA QUANTITY/QUALITY			
				FORM(S)	RECORDS	YEARS	REMARKS
7. COST DATA (CONT)	FROST AND SULLIVAN INC.	NEW YORK, NY	DEFENSE CONTRACTS/ COST INFORMATION	LISTING	-	1962-1975	PROVIDES HISTORICAL VISIBILITY INTO INDIVIDUAL CONTRACTS BY PRODUCT CATEGORIES AGAINST THE C-130 AIRCRAFT. SOME CONTRACTS REFLECT SPECIFIC AIR FORCE C-130E APPLICATION. INDIVIDUAL CONTRACT DOLLAR VALUE IS REFLECTED FOR MOST CONTRACTS LISTED.
	C-130E UNITS						
	62 MAW	MCCHORD AFB, WA	MAINTENANCE COST SYSTEM (MCS) EXECUTIVE MANAGEMENT SUMMARIES AFR 177-380	MONTHLY REPORTS	-	JUL'75-DEC-76	PROVIDES WEAPON SYSTEM COSTS DIRECT AND INDIRECT BY EACH INDIVIDUAL UNIT. INFORMATION OBTAINED WAS ONLY FROM THE 3 UNITS LISTED.
	314 TAW	LITTLE ROCK AFB AR					
	317 TAW	POPE AFB, NC					
	AFLC/LOLMA, SCALC/[illegible]	WPAFB, OH MCCLELLAN AFB, CA	LOGISTICS SUPPORT COST RANKING (IROS/KOSI) SYSTEM	QUARTERLY REPORTS		1973-1976	THE LOGISTIC SUPPORT COST RANKING (IROS/KOSI) REPORTS ARE DESIGNED TO PROVIDE AN ESTIMATE OF COST TO REPAIR, MAINTAIN, AND SUPPLY A SPECIFIC ITEM (WUC) FOR A GIVEN PERIOD. IT PROVIDES FIELD MANHOUR COSTS, SPECIALIZED REPAIR ACTIVITY COST, SPARES/MATERIAL COST AND PACKAGING/SHIPPING COST. IT ALSO CONTAINS OTHER DATA SUCH AS SAFETY AND AVAILABILITY. COSTS NOT INCLUDED ARE: GROUND SUPPORT EQUIPMENT, MODIFICATION HARDWARE, AND SELECTED SPARES. THE KOSI COSTS DATA WERE USED IN THIS STUDY TO DETERMINE THE TOP 10 WUC LSC RANKING. IT WILL NOT BE USED FOR ICC BECAUSE IT WAS NOT DESIGNED TO CAPTURE TOTAL COSTS OF ALL SYSTEMS ON AIRCRAFT.

APPENDIX C

CACE (FLEET) MODEL EQUATIONS AND FACTORS

TABLE C-1

CACE (FLEET) MODEL EQUATIONS AND FACTORS

(REF. AFM 173-10 TABLE 51)

SEC.	PARA.	ITEM	FORMULA/ELEMENTS	*FILE	AFR-173-10 TABLE	FACTOR	REMARKS
I		RECURRING INVESTMENT AND MISCELLANEOUS LOGISTICS	A+B+C+D+E+F+G+H				
	A.	COMMON S.E. (INCL. SPARES)	= (UE)x(AGE FACTOR) (001) (180)				
			001=UNIT EQUIP (OR ACFT/SQD)	C		16	16 WAS USED AS THE AVERAGE NUMBER OF ACFT/SQD AS A CONSTANT.
			180=COMMON SUPPORT EQUIP. (INCL. SPARES) (COST/UE/YEAR)	C	VOL. I T-10	FY 76 $6011	- - -
	B.	AVIATION FUEL	=(UE)x(FH)x(FUEL FACTOR) (001)(005) (140)				
			005=UTILIZATION RATE (FLYING HRS/UE/YR)	V		-	ACTUAL DATA WERE USED FOR EACH YEAR AS A VARIABLE. REFER TO TABLE C-2 FOR YEARLY VALUES.
			140=FUEL AVIATION (COST/FH)	V	VOL. I T-3	FY 76 $289	FOR PRIOR YEARS THE AFM 173-10/ AFR 172-3 VALUES WERE USED WHERE AVAILABLE FROM REVISIONS. THEN EACH YEARS VALUE WAS ESCALATED TO 1976 DOLLARS. REFER TO TABLE C-2 FOR YEARLY VALUES.
	C.	AIRCRAFT MAINTENANCE BASE LEVEL (MATERIAL ONLY)	= [(UE)x(FH)x(BM/FH FACTOR)] + [(UE)x(BM/UE FACTOR)] (001)(115) (145) (001) (150)				
			145=BASE LEVEL ACFT MAINT. MATERIAL COST/FH	C	VOL. I T-7	FY 76 $62	- - -
			150=BASE LEVEL ACFT MAINT. MATERIAL COST/UE/YR	-	VOL. I	0	NOT APPLICABLE TO C-130E.

* V-VARIABLE
C-CONSTANT

TABLE C-1 (Cont'd)

CACE (FLEET) MODEL EQUATIONS AND FACTORS

(REF. AFR 173-10 TABLE 61)

SEC.	PARA.	ITEM	FORMULA/ELEMENTS	*FILE	AFR-173-10 TABLE	FACTOR	REMARKS
I							
	D.	DEPOT LEVEL MAINTENANCE	(UE)x(FH)x(DM/FH FACTOR) + (001)(005) (155)				
			(UE)x(DM/UE FACTOR) (001) (160)				
			155=DEPOT MAINT(COST/FH)	V	-	-	ACTUAL DATA WERE USED FOR YEARS 1971 THROUGH 1975 AND THE VALUES WERE ESCALATED TO 1976 DOLLARS. REFER TO TABLE C-2 FOR THE YEARLY VALUES.
			160=DEPOT MAINT(COST/UE/YR)	C	VOL. I T-6	FY 76 $58,902	
	E.	MODIFICATIONS CLASS IV (INCLUDING INITIAL SPARES)	(UE)x(FAC)x(MOD FACTOR) (001)(170) (175)				
			170=FLY AWAY COST (FAC) CURRENT DOLLAR COST/ACFT	C	VOL. I T-11	FY 76 $2.98 MIL.	
			175=MODIFICATION CLASS IV + SPARES COST/FAC DOLLARS (FACTOR .004494)	C	VOL. I T-51A	.004494	
	F.	MUNITIONS TRAINING	[(UE)x(UE-RELATED FACTOR)] + (001) (135)				NOT APPLICABLE TO C-130E.
			[(UE)x(CR)x(CREW RELATED FAC)] (001)(010) (137)				NOT APPLICABLE TO C-130E.
			010=CREW RATIO (CR) (CREWS/ACFT)	V		-	CREWS RATIO FACTORS WERE ESTABLISHED BY YEAR BASED ON ACTUAL ACFT. UTILIZATION RATES. REFER TO TABLE C-2 FOR YEARLY VALUES.

* V-VARIABLE
C-CONSTANT

TABLE C-1 (Cont'd)

CACE (FLEET) MODEL EQUATIONS AND FACTORS

(REF. AFR 173-10 TABLE 51)

SEC.	PARA.	ITEM	FORMULA/ELEMENTS	*FILE	AFR-173-10 TABLE	FACTOR	REMARKS
I	F.	MUNITIONS TRAINING (CONTINUED)	135=MUNITIONS TRAINING (RATE/UE/YR)	-	VOL. I T-30B	-	NOT APPLICABLE TO C-130E.
			137=MUNITIONS TRAINING (RATE/CREW/YR)	-	VOL. I	-	NOT APPLICABLE TO C-130E.
	G.	REPLENISHMENT SPARES	(UE)x(FH)x(REP SPARES FAC.) (001)(005) (165)				
			165=REPLENISHMENT SPARES FACTOR (COST/FH)	C	VOL. I T-9	FY 76 $74	- - -
	H.	VEHICULAR EQUIPMENT	(PPE & BOS/RPH MMY)x(UE FAC.) (235) (130)				
			130=VEHICULAR EQUIPMENT (MARGINAL COST/MIL. MY)	C	VOL. I T-51A	FY 76 $47	- - -
			235=PPE MMY & BOS/RPH MMY (CODE 225+CODE 230)		-	-	COMPUTED BY MODEL SUB-ROUTINE USING INPUT FROM OTHER MODEL CODE.
			225=PPE OMY & BOS/RPH OMY (CODE 015+CODE 030+CODE 045)	-	-	-	COMPUTED BY MODEL SUB-ROUTINE USING INPUT FROM OTHER MODEL CODE.
			230=PPE AMY & BOS/RPH AMY (CODE 020+CODE 035+CODE 050)	-	-	-	COMPUTED BY MODEL SUB-ROUTINE USING INPUT FROM OTHER MODEL CODE.
		PAY AND ALLOWANCES (P&A)	I+J				
	I.	MILITARY (P&A)	[(PPE/BOS/RPH OMY)x(PAY FAC.)] (015+030+045) (085) + [(PPE/BOS/RPH AMY)x(PAY FAC.)] (020+035+050) (090)				
			015=PRIMARY PROGRAM ELEMENT-OFFICERS (MY/SQD/YR)	V	-	-	COMBINATION OF ACTUAL DATA AND PLANNING FACTORS WERE UTILIZED WHICH CONSIDERED CREW, MAINT., WING/BASE STAFF, SECURITY, AND MUNITIONS OFFICERS. REFER TO TABLE C-2 FOR THE YEARLY VALUES.

* V-VARIABLE
C-CONSTANT

TABLE C-1 (Cont'd)

CACE (FLEET) MANEL EQUATIONS AND FACTORS

(REF. AFM 173-10 TABLE 61)

SEC.	PARA.	ITEM	FORMULA/ELEMENTS	*FILE	AFR-173-10 TABLE	FACTOR*	REMARKS
II	I.	MILITARY (P&A) (CONTINUED)	030=BOS/BPN OFFICERS (MY/SQD/YR)	C	-	-	PLANNING FACTOR ESTIMATES WERE GENERATED BY COMPUTER SUB-ROUTINE.
			045=MEDICAL DESP. OFFICERS (MY/SQD/YR)	C	-	-	PLANNING FACTOR ESTIMATES WERE GENERATED BY COMPUTER SUB-ROUTINE.
			085=P&A(WORLD WIDE RATE/OFF MY)	C	VOL. I T-21	FY 76 $21,549	- - -
			020=PRIMARY PROGRAM ELEMENT AIRMAN (MY/SQD/YR)	V	-	-	COMBINATION OF ACTUAL DATA AND PLANNING FACTORS WERE UTILIZED WHICH CONSIDERED CREW, MAINTENANCE, WING/BASE STAFF, SECURITY AND MISCELLANEOUS AIRMAN. REFER TO TABLE C82 FOR THE YEARLY VALUES.
			035=BOS/BPN AIRMAN (MY/SQD/YR)	C	-	-	PLANNING FACTOR ESTIMATES WERE GENERATED BY COMPUTER SUB-ROUTINE.
			060=MEDICAL DISPENSARY AIRMAN (MY/SQD/YR)	C	-	-	PLANNING FACTOR ESTIMATES WERE GENERATED BY COMPUTER SUB-ROUTINE.
			090=P&A(WORLD WIDE RATE/AMN MY)	C	VOL. I T-21	FY 76 $9,438	- - -
	J.	CIVILIAN P&A	(PPE/BOS/BPN CMY)x(PAY FAC.) (025+040+055) (100)				
			025=PRIMARY PROGRAM ELEMENT-CIVILIANS (MY/SQD/YR)	C	-	7.59*	COMBINATION OF ACTUAL DATA FOR MAINTENANCE AND PLANNING FACTOR ESTIMATE FOR WING/BASE STAFF WAS UTILIZED.

* V-VARIABLE
C-CONSTANT

TABLE C-1 (Cont'd)

CACE (FLEET) MODEL EQUATIONS AND FACTORS

(REF. AFM 173-10 TABLE 51)

SEC.	PARA.	ITEM	FORMULA/ELEMENTS	*FILE	AFM-173-10 TABLE	FACTOR	REMARKS
II.	J.	CIVILIAN P&A (CONTINUED)	040-BOS/BPN - CIVILIAN (MY/SQN/YR)	C	-	-	PLANNING FACTORS ESTIMATES WERE GENERATED BY COMPUTER SUB-ROUTINE.
			066-MEDICAL DISPENSARY CIVILIANS (MY/SQN/YR)	C	-	-	PLANNING FACTORS ESTIMATES WERE GENERATED BY COMPUTER SUB-ROUTINE.
			100-P&A CIVILIAN (COMMAND RATE/CIVILIAN MY)	L	VOL. I T-25	FY 76 MAC $18,224	- - -
III.		MAJOR FORCE PROGRAM (MFP)-(BOS/BPN SUPPORT):	K+L				
	K.	PPE MANPOWER	(PPE MY)x(BOS/BPN FACTOR) (015+020+025) (125)				
			125-BOS/BPN(INCL. DISPENSARY) (MARGINAL COST/MY)	C	VOL. I T-51A	FY 76 MAC $311	- - -
	L.	BOS/BPN MANPOWER	(BOS/BPN MY)x(BOS/BPN FAC.) (030+045+035+050+040+065)x(125)				
IV.		MEDICAL - SUPPORT OF:	M+N				
	M.	OFFICERS	(PPE AND BOS/BPN/MED OMY) x (015+030+046) (MEDICAL FACTOR) (115)				
			115 MEDICAL OFF SUPPORT (MARGINAL COST-OFF MY)	C	VOL. I T-51A	FY 76 $560	- - -
	N.	AIRMEN	(PPE AND BOS/BPN/MED AMY)x (020+035+050) (MEDICAL FACTOR) (120)				
			120 MEDICAL-AIRMAN SUPPORT (MARGINAL COST-AMN MY)	C	VOL. I T-51A	FY 76 $493	- - -

V-VARIABLE

* C-CONSTANT

TABLE C-1 (Cont'd)
CACE (FLEET) MODEL EQUATIONS AND FACTORS
(REF. AFH 173-10 TABLE 61)

SEC.	PARA.	ITEM	FORMULA/ELEMENTS	*FILE	AFR-173-10 TABLE	FACTOR	REMARKS
V		PERSONNEL SUPPORT	O+P				
	O.	PCS-OFFICERS	(PPE AND BOS/RPM/MED OMY) x (015+030+045) (PCS FACTOR) (105)				
			105 PCS-OFFICERS (CONUS-OS RATE/MY)	C	VOL. I T-27A	FY 76 $2,788	THE AVERAGE OF CONUS AND OVERSEAS PLANNING FACTOR ESTIMATES WERE UTILIZED.
	P.	PCS-AIRMAN	(PPE AND BOS/RPM/MED AMY) x (020+035+050) (PCS FACTOR) (110)				
			110 PCS-AIRMAN (CONUS-OS RATE MY)	C	VOL. I T-27A	FY 76 $1,482	THE AVERAGE OF CONUS AND OVERSEAS PLANNING FACTOR ESTIMATES WERE UTILIZED.
VI		PIPELINE COSTS	Q+R+S+T+U+V+W+X+Y				
		ACQUISITION-OFFICERS					
	Q.	PILOTS	(UE)x(CR)x(PILOT PER CREW)x (001)(010) (060) (TURNOVER FACTOR) x (250)				
			(ACQUISITION FACTOR) (210)				
			060-AIRCREW RATED OFFICER PILOT (MY/AIRCRAFT/YEAR)	C	VOL. I T-14, T-14A, T-14B	CURRENT = 2	- - -
			250-PILOT TURNOVER RATE (FACTOR = .063)	C	VOL. I T-51A	CURRENT = .063	- - -
			210-ACQUISITION-OFFICER (COST PER MAN-INCLUDING ATTRITION)	C	VOL. I T-51A	FY 76 $35K	- - -

* V-VARIABLE
C-CONSTANT

TABLE C-1 (Cont'd)

CACE (FLEET) MODEL EQUATIONS AND FACTORS

(REF. AFR 173-10 TABLE 51)

SEC.	PARA.	ITEM	FORMULA/ELEMENTS	*FILE	AFR-173-10 TABLE	FACTOR	REMARKS
VI	R.	NON-PILOT AIRCREW-OFFICERS	(UE)x(CR)x(NON-PILOT/CREW) (001)(010) (065) x (TURNOVER FACTOR) x (255) (ACQUISITION FACTOR) (210)				
			065-AIRCREW RATED OFF OTHER (MY/AIRCRAFT/YR)	C	VOL. I T-14, T-14A, T-14B	CURRENT = 1	- - -
			255-OTHER AIRCREW TURNOVER (FACTOR .059)	C	VOL. I T-51A	CURRENT = .059	
	S.	NON-AIRCREW-OFFICER	(NONRATED OFF MY)x (192) (TURNOVER FACTOR)x (260) (ACQUISITION FACTOR) (210)				
			192-NON RATED OFFICER MY/SQD [(CODES 015+030+045)] - [(CODE 0001)x (CODE 010)x(CODES 060+065)]	C	-	-	GENERATED BY COMPUTER SUB-ROUTINE BASED ON OTHER MODEL FACTORS.
			260-NON-AIRCREW TURNOVER RATE (FACTOR)	C	VOL. I T-51A	CURRENT = .094	- - -
	T.	ACQUISITION AIRMAN	(PPE AND BOS/RPM/NED AMY) x (230) (TURNOVER FACTOR) x (265) (ACQUISITION FACTOR) (215)				
			230-PPE AMY AND BOS/RPM AMY(CODES 020+035+050)	C	-	-	- - -
			265-AIRMAN TURNOVER RATE (FACTOR .134)	C	VOL. I T-51A	CURRENT = .134	- - -
			215-ACQUISITION AIRMAN (COST/MY)	C	VOL. I T-51A	FY 76 $3,120	- - -

* V-VARIABLE
C-CONSTANT

TABLE C-1 (Cont'd)

CACE (FLEET) MODEL EQUATIONS AND FACTORS

(REF. AFR 173-10 TABLE 61)

SEC.	PARA.	ITEM	FORMULA/ELEMENTS	*FILE	AFR-173-10 TABLE	FACTOR	REMARKS
VI	U.	TRAINING-OFFICERS-AIRCREW PILOTS	(UE)x(CR)x(PILOTS/CREW)x (001)(010) (060) (TURNOVER FACTOR) x (250) (UPT TRAINING FACTOR) (185)				
			185-UPT TRAINING (VARIABLE COST/GRADUATE OFFICER)	C	VOL. I T-51A	FY 76 $110,975	- - -
	V.	TRAINING-OFFICERS-AIRCREW OTHER	(UE)x(CR)x(AIRCREW-OTHER MY) (001)(010) (066) x (TURNOVER FACTOR) x (255) (TRAINING FACTOR) (190)				
			190-AIRCREW OFFICER TRAINING (EXCLUDING UPT) (VARIABLE COST/GRADUATE OFFICER)	C	VOL. I T-51A	FY 76 $37,253	- - -
	W.	TRAINING OFFICERS-NON-AIRCREW	(NON-AIRCREW MY) x (192) (TURNOVER FACTOR) x (260) (TRAINING FACTOR) (195)				
			195-NON-RATED OFFICER TRAINING (MARGINAL COST/GRADUATE OFFICER)	C	VOL. I T-51A	FY 76 $4,030	- - -
	X.	TRAINING AIRMAN-BASE LEVEL AIRCRAFT MAINTENANCE	(MAINT. MY) x (TURNOVER FACTOR)x (075) (265) (TRAINING FACTOR) (200)				
			075-BASE MAINT. AIRMAN (MY/SQD/YEAR)	C	-	429.88	ACTUAL DATA COLLECTED FOR 1976 WAS USED.

* V-VARIABLE
C-CONSTANT

TABLE C-1 (Cont'd)

CACE (FLEET) MODEL EQUATIONS AND FACTORS

(REF. AFM 173-10 TABLE 51)

SEC.	PARA.	ITEM	FORMULA/ELEMENTS	*FILE	AFR-173-10 TABLE	FACTOR	REMARKS
VI	X.	TRAINING AIRMAN-BASE LEVEL AIRCRAFT MAINTENANCE (CONTINUED)	266-AIRMAN TURNOVER RATE (FACTOR .134) 200-AIRMAN MAINT. FUNCTION-TRAINING (MARGINAL COST/GRADUATE AIRMAN)	C V	VOL. I T-51A VOL. I T-51A	CURRENT • .134 FY 76 $6,266	- - -
	Y.	TRAINING AIRMAN	(PPE AND BOS/BCM ANY - MAINT.ANY) (230) (035) x (TURNOVER FACTOR)x(TRAINING (265) 1 FACTOR) (265) 205-AIRMAN OTHER TRAINING (MARGINAL COST/GRADUATE AIRMAN)	C	VOL. I T-51A	FY 76 $2,630	- - -
	Z.	TOTAL CACE OUTPUT (BAS) COST	(A+B+C---+L---+X+Y)	-	-	-	- - -

• V-VARIABLE
C-CONSTANT

TABLE C-2
CACE MODEL CODE/VALUES

MODEL CODE	DESCRIPTION	UNIT OF MEASURE	*TYPE FILE	VALUE(S)
001	UNIT EQUIPMENT (UE)	NUMBER/SQ	C	16
005	UTILIZATION RATE (UR)	FLY HRS/UE/YR	V	62=1709, 63=991, 64=1022, 65=1102, 66=1505, 67=1260, 68=1112, 69=884 70=806, 71=765, 72=738, 73=651, 74=576, 75=576, 76=554
010	CREW RATIO	CREWS/ACFT	V	62=3.0, 63 thru 65=2.0, 66=2.5, 69 thru 76=2.0
015	PRI PROG. ELEMENT - OFFICERS	MY/SQ/YR	V	62=165.072, 63 thru 65=117.072, 66=141.072, 67 thru 76=117.072
020	PRI PROG. ELEMENT - AIRMAN	MY/SQ/YR	V	62=564.88, 63 thru 65=532.888, 66=548.888, 67 thru 76=532.888
025	PRI PROG. ELEMENT - CIVILIAN	MY/SQ/YR	C	7.69
030	BOS/RPM - OFFICERS	MY/SQ/YR	C	**
035	BOS/RPM - AIRMAN	MY/SQ/YR	C	**
040	BOS/RPM - CIVILIAN	MY/SQ/YR	C	**
045	MEDICAL DESP. - OFFICERS	MY/SQ/YR	C	**
050	MEDICAL DESP. - AIRMAN	MY/SQ/YR	C	**
055	MEDICAL DESP - CIVILIAN	MY/SQ/YR	C	**
060	AIRCREW OFFICER - PILOT	MY/ACFT/YR	C	2.0

*V-Variable
C-Constant

** - Generated by computer sub-routine

TABLE C-2

CACE MODEL CODE/VALUES

MODEL CODE	DESCRIPTION	UNIT OF MEASURE	*TYPE FILE	VALUE(S)
065	AIRCREW OFFICER - OTHER	MY/ACFT/YR	C	1.0
066	AIRCREW AIRMAN	MY/ACFT/YR	C	2.0
075	BASE MAINTENANCE - AIRMAN	MY/ACFT/YR	C	429.86
085	PAY AND ALLOWANCES - OFFICER	/OFF MY	C	21649.00
090	PAY AND ALLOWANCES - AIRMAN	$/ASN MY	C	9436.00
100	PAY AND ALLOWANCES - CIVILIAN	$/CIV MY	C	14224.00
105	PCS - OFFICERS	$/OFF MY	C	2788.00
110	PCS - AIRMAN	$/ASN MY	C	1452.00
115	MEDICAL OFFICER SUPPORT	$/MIL MY	C	660.00
120	MEDICAL AIRMAN SUPPORT	$/MIL MY	C	493.00
125	BOS/RPH (INC. DISPENSARY)	$/MY	C	311.00
130	VEHICULAR EQUIPMENT	$/MIL MY	C	47.00
135	MUNITIONS TRAINING	$/UE/YR	C	0.00
137	MUNITIONS TRAINING	$/CREW/YR	C	0.00
140	FUEL AVIATION	$/FH	V	62 thru 65=122, 66-67=123, 68-69=143, 70 thru 73=138, 74=406, 75=393, 76=289
145	BASE LEVEL ACFT MAINTENANCE (MATERIAL COST)	$/FH	C	62.00

*V-Variable
C-Constant

** - Generated by computer sub-routine

TABLE C-2

CACE MODEL CODE/VALUES

MODEL CODE	DESCRIPTION	UNIT OF MEASURE	*TYPE FILE	VALUE(S)
150	BASE LEVEL ACFT MAINTENANCE (MATERIAL COST)	$/UE/YR	C	0.00
155	DEPOT MAINTENANCE	$/FH	V	62 thru 69=492, 70=602, 71-72=562, 73=606, 74=503, 75-76=313
160	DEPOT MAINTENANCE	$/UE/YR	C	58902.00
165	REPLENISHMENT SPARES	$/FH	C	74.00
170	FLYAWAY $(FAC)	$/ACFT	C	2,980000.00
175	MODIFICATIONS CLASS IV - WITH SPARES	$/FAC $	C	.004494
180	SUPPORT EQUIPMENT, COMMON	$/UE/YR	C	6011.00
185	UPT TRAINING	$/GRAD OFF	C	110975.00
190	AIRCREW OFFICER TRAINING - (EXCLUDING UPT)	$/GRAD OFF	C	37263.00
192	NONRATED OFFICER	MY/SQ	C	**
196	NONRATED OFFICER TRAINING	$/GRAD OFF	C	4030.00
200	AIRMAN MAINTENANCE FUNCTIONAL TRAINING	$/GRAD AMN	C	6265.00
205	AIRMAN - OTHER TRAINING	$/GRAD AMN	C	2630.00
210	ACQUISITION - OFFICER	$/MAN	C	36000.00
215	ACQUISITION - AIRMAN	$/MAN	C	3120.00
225	PPE ONY & BOS/RPM ONY	MY/SQ	C	**

*V-Variable
C-Constant

** - Generated by computer sub-routine

TABLE C-2
CACE MODEL CODE/VALUES

MODEL CODE	DESCRIPTION	UNIT OF MEASURE	*TYPE FILE	VALUE(S)
230	PPE MW & BOS/BPH MW	MW/SQ	C	**
235	P.T.E MW & BOS/BPH MW	MW/SQ	C	**
250	PILOT TURNOVER RATE - OFFICER	FACTOR	C	.063
255	OTHER AIRCREW TURNOVER RATE - OFFICER	FACTOR	C	.059
260	NON-AIRCREW TURNOVER RATE - OFFICER	FACTOR	C	.054
265	AIRMAN TURNOVER RATE	FACTOR	C	.134

*V-Variable
C-Constant

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